REHDER, PETER D., Ph.D. Person-Centered Approaches to Examining Links Between Self-Regulation and Conduct Problems, Attention-Deficit/Hyperactivity Disorder, and Callous-Unemotional Behaviors in Childhood. (2019)
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Over the past two decades, the study of self-regulation and its associations with emerging psychopathology has become a major pursuit in developmental science. Early-childhood emotion regulation (ER) and executive function (EF), in particular, are interrelated aspects of self-regulation that have garnered extensive research and are theorized to promote social competence school readiness and achievement, and adjustment. However, the development of self-regulation is a complex process that occurs through coaction at multiple levels of analysis. Three studies were conducted to examine biobehavioral emotion responding in infancy, early childhood EF, and their prospective influences on trajectories of conduct problems (CPs), attention-deficit/hyperactivity disorder (ADHD), and callous-unemotional (CU) behaviors using multiple person-centered approaches. Study 1 used latent profile analysis (LPA) to prospectively examine the synchrony and asynchrony of infant behavioral reactivity, cortisol reactivity, and ER behaviors at 6, 15, and 24 months of age to determine whether groups of infants evidenced different patterns of arousal and regulation; and whether such patterns were bidirectionally related to parenting behavior over the same span of time. Study 2 used longitudinal latent class analysis (LLCA) to examine joint trajectories of CPs, ADHD symptoms, and CU behaviors from 3 years old to 5th grade in order to assess examine heterogeneity in CPs based on the presence of ADHD and CU behaviors. Study 3 built upon the prior two studies by in by investigating associations of infants' emotional arousal and regulation with their later CP/ADUD/CU trajectories, as well as the role of early childhood EF in mediating these prospective associations. Results from Study 1 indicated that there is observable variation in infants' patterns of behavioral reactivity, cortisol reactivity, and ER behaviors across infancy, and that infant emotion responding and parent sensitivity and harsh-intrusion were bidirectionally predictive of one another. Results from Study 2 showed that children did follow differing trajectories of CPs, but that these varied based on who reported their behavior (parents, teachers, or both), rather than on trajectories of ADHD symptoms and CU behaviors. In addition, these joint trajectories differentiated children's likelihood of meeting diagnostic criteria for oppositional defiant disorder, conduct disorder, and ADHD, as well as clinically significant levels of CU behaviors, during preadolescence. Finally, results from Study 3 indicated that infants' patterns of emotion responding were not prospectively related to their CP/ADHD/CU trajectories or their early childhood EF. However, better EF did significantly predict a decreased likelihood of following trajectories characterized by high problem behavior as rated by both parents and teachers, parents only, and teachers only. The implications for understanding the early development of self-regulation, CPs, ADHD, and CU behaviors are discussed, as is the utility of innovative person-centered approaches for understanding these phenomena.

PERSON-CENTERED APPROACHES TO EXAMINING LINKS BETWEEN SELF-REGULATION AND CONDUCT PROBLEMS, ATTENTION-DEFICIT/HYPERACTIVITY DISORDER, AND CALLOUS-UNEMOTIONAL BEHAVIORS IN CHILDHOOD

by

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APPROVAL PAGE

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CHAPTER I

GENERAL INTRODUCTION

Over the past two decades, the study of self-regulation and its associations with emerging psychopathology has become a major pursuit in developmental science. Early-childhood emotion regulation (ER) and executive function (EF), in particular, are interrelated aspects of self-regulation that have garnered extensive research and are theorized to promote social competence school readiness and achievement, and adjustment (Calkins, 2007; Morrison, Cameron Ponitz, & McClelland, 2010). Thus, developing ER and EF (and self-regulation, broadly) abilities has been deemed a major task of early childhood (Calkins, 2007). However, the development of self-regulation is a complex process that occurs through coaction at multiple levels of analysis (i.e., biological, psychological, behavioral, and social; Calkins & Marcovitch, 2010; Gottlieb, 2007).

Importantly, there has been increased attention paid the biopsychosocial nature of emotion and ER, in particular, especially with respect to the contributions of physiological processes (Dennis, Buss, & Hastings, 2012). Although this greater focus on multiple levels of analysis has led to improved understanding of how the physiology and behavior of children’s emotion responses are related, questions still remain, including the degree to which behavioral reactivity (i.e., affect), physiological reactivity, and ER behavior are jointly activated or not in response to stress. The presence of inconsistent correlations among these aspects of the emotion process (Lewis, 2011) suggests that individual differences exist in children's patterns of arousal and regulation (Fox, Kirwan, & Reeb-Sutherland, 2012). These differential patterns may have distinct developmental origins and consequences for later functioning across domains, including for bidirectional relations with developing EF and for the emergence of psychopathology, including conduct problems (Beauchaine & McNulty, 2013; Nigg & Casey, 2005; Shipman, Schneider, & Brown, 2004).

Conduct problems (CPs) appearing in childhood and adolescence present public health and safety concerns (Eme, 2015; Vaughn, Salas-Wright, DeLisi, & Maynard, 2014), as well as personal risks to the children who evidence them, including deficits in social competence (Chen, Drabick, & Burgers, 2015), lower school readiness and achievement (Lewis, Asbury, & Plomin, 2017), and worse mental and physical health (Bevilacqua, Hale, Barker, & Viner, 2017). However, there is significant clinical heterogeneity in the onset, presentation, and course of CPs across childhood and adolescence, indicating need for examining subtypes of CPs in order to identify those at greatest risk for lasting antisocial behavior and related negative outcomes (Frick & Viding, 2009; Sebastian et al., 2014). Attention-deficit/hyperactivity disorder (ADHD) and callous-unemotional (CU) behaviors have been posited as means of differentiating subtypes of childhood CPs, as both have been independently associated with more severe and persistent CPs over time (Danforth, Connor, & Doerfler, 2016; Odgers et al., 2008; Frick & White, 2008, Rowe et al., 2010).

The Current Studies

Given the potential heterogeneity in both emotion functioning and CPs, the current studies utilized person-centered approaches to examine patterns of emerging emotional reactivity and regulation during infancy and early childhood, patterns of CPs, ADHD, and CU behavior trajectories during early- and middle childhood, and the links between these phenomena over time. Study 1 used latent profile analysis (LPA) to prospectively examine the synchrony and asynchrony of infant behavioral reactivity, cortisol reactivity, and ER behaviors at 6, 15, and 24 months of age to determine whether groups of infants evidenced different patterns of arousal and regulation. This approach classifies individuals into profiles based on having similar scores on a set of indicators (Geiser, 2013) and presents an innovative means for assessing whether groups of infants show differential emotional responding that is not reflected in the overall correlations characterized by common variable-centered approaches. Additionally, I examined the stability and change in infants' patterns of arousal and regulation from 6 to 24 months using latent transition analysis (LTA), which tests whether infants move from one profile to another over time (Lanza, Patrick, & Maggs, 2010). Additionally, I assessed bidirectional, prospective associations of infants' emotion profiles with parent behavior (i.e., sensitivity and harsh-intrusion) across infancy, given that parent–child relationships are thought to play a major role in children's developing ER abilities in early life (Calkins, 2009; Calkins & Dollar, 2014; Sameroff, 2010; Sroufe, 1996).

Study 2 used longitudinal latent class analysis (LLCA) to examine joint trajectories of CPs, ADHD, and CU behaviors from 3 years old to 5th grade. Like LPA (but with dichotomous indicators), LLCA allows for the observation of heterogeneity in children's behavior that is not reflected by variable-centered approaches. Whereas previous research has studied children's trajectories of CPs, ADHD, and CU behaviors separately, the study assessed them simultaneously in order to examine whether children's CPs present with differing patterns of ADHD and CU behaviors over time. In addition, I tested the predictive and clinical utility of the resulting psychopathology trajectories by examining associations between children's trajectory membership and diagnoses of oppositional defiant disorder (ODD), conduct disorder (CD), and ADHD at 12 years old.

Finally, Study 3 built upon Studies 1 and 2 by investigating associations of infants' emotional arousal and regulation with their later CP/ADHD/CU trajectories, including an analysis of EF as a potential mediating factor. Both ER and EF develop rapidly during early life (Garon, Bryson, & Smith, 2008; Sameroff, 2010), and have been theorized to influence one another and become highly integrated over time (Calkins & Marcovitch, 2010). However, limited empirical research has tested longitudinal associations between ER and EF. Study 3 attempted to fill a gap in the existing literature by examining the influence of infants' emotion profiles from Study 1 as predictors of their EF during early childhood. Children's ability to control both their emotions and cognitions promotes better multi-domain functioning, but and disruptions and deficits in the development of self-regulation have been implicated in the emergence of psychopathology (Beauchaine & McNulty, 2013; Nigg & Casey, 2005; Shipman, Schneider, & Brown, 2004). Therefore, Study 3 also examined the influence of infants' emotion profiles on their psychopathology trajectories from Study 2, mediated through their EF abilities.

Conceptual Framework

The current studies were conceptualized from developmental science (a.k.a., developmental systems, biopsychosocial; Gottlieb, 2007; Magnusson & Cairns, 1996) and developmental psychopathology (Cicchetti & Toth, 2009; Rutter & Sroufe, 2000). Drawing on developmental science principles, I view children as developing as integrated organisms that do not exist in isolation, but rather they exist in the context of maturational, experiential, and cultural process that contribute synergistically to children's holistic development (Magnusson & Cairns, 1996). Further, development occurs through complex, reciprocal coactions over time at multiple levels of analysis internal and external to individuals (e.g., genetic, neurological, physiological, cognitive, behavioral, environmental; Gottlieb, 2007). The current studies tested these principles by examining multiple aspects of infants' emotion responding and longitudinal associations with parenting, EF, and comorbid (rather than isolated) trajectories of CPs, ADHD, and CU behaviors.

Drawing on developmental psychopathology principles, I consider the study of causal mechanisms, rather than risk factors alone, as critical for understanding the development of psychopathology (Rutter & Sroufe, 2000). Further, the study of normative development is important for informing understanding of psychopathological development, and vice versa (Cicchetti & Toth, 2009). Thus, Study 3 attempted to explain the *how* aspects of normative emotion, ER, and EF development contribute to emerging CPs, ADHD, and CU behaviors. Additionally, the developmental psychopathology principles of multifinality and equifinality suggest that children with the same risk or protective factors can have varied developmental outcomes, and that children can reach the same outcome through multiple differing developmental pathways (Sroufe, 1997). Studies 2 and 3 tested these principles by how children with differential patterns of emotion functioning may progress to CP/ADHD/CU trajectories of potentially differing course and severity. Thus, the principles of both developmental science and developmental psychopathology are reflected in the conceptualization, hypotheses, and methods of the studies herein.

CHAPTER II

STUDY 1. LATENT PROFILES OF INFANT BEHAVIORAL REACTIVITY, CORTISOL REACTIVITY, AND EMOTION REGULATION BEHAVIORS AND THEIR ASSOCIATION WITH PARENTING AT 6, 15, AND 24 MONTHS OLD

Introduction

Emotion regulation (ER) has become an important construct studied in developmental science due to its potential influences on numerous domains of functioning throughout the life course, including social competence (Calkins & Marcovitch, 2010), school readiness and achievement (Morrison, Cameron Ponitz, & McClelland, 2010), and adjustment (Barrett, 2013). The ability to express, control, channel, and use their emotions serves as a basis for children's ability to get along with others, focus on important tasks, and behave appropriately across settings. As a result, developing ER, along with other aspects of self-regulation, has been deemed a major task of early childhood (Calkins, 2007).

Although ER development is certainly an important developmental task, it has been historically conceptualized and measured in different ways, as have emotions in general, and these differences have important implications for how emotion and ER are understood as developmental phenomena. Drawing on multiple prevailing perspectives (Campos, Walle, Dahl, & Main, 2011; Cole, Martin, & Dennis, 2004), I define emotion as the biopsychosocial process of consciously or subconsciously appraising the meaning and importance of internal and external stimuli. This process can occur at the neural, physiological, cognitive, and behavioral levels—often in combination. Likewise, I define ER as strategies, skills, behaviors, and cognitions that modulate emotional experiences. Like elicited emotions, ER can be conscious or subconscious, automatic or intentional (Calkins & Marcovitch, 2010). Importantly, emotion and ER are highly integrated, but distinct processes that coact as part of the overall emotional experience. Extensive previous research has demonstrated that separate consideration of emotion and ER aids understanding how children experience, learn to control, and learn to use their emotions (Cole et al., 2004).

In recent years, there has been increased attention paid the biopsychosocial nature of emotion and ER, particularly with respect to the contributions of physiological processes (Dennis, Buss, & Hastings, 2012). Although this greater focus on multiple levels of analysis has led to improved understanding of how the physiology and behavior of children's emotion responses are related, questions still remain, including the degree to which behavioral reactivity (i.e., affect), physiological reactivity, and ER behavior are jointly activated or not in response to stress. The presence of inconsistent correlations among these aspects of the emotion process (Lewis, 2011) suggests that individual differences exist in children's patterns of arousal and regulation (Fox, Kirwan, & Reeb-Sutherland, 2012). These differential patterns may have distinct developmental origins and consequences for later functioning across domains. The current study used a person-centered approach to examine whether infants show distinct patterns of behavioral reactivity, neuroendocrine reactivity (i.e., cortisol), and ER behaviors at 6, 15, and 24 months old. It also assessed current and prospective associations of these profiles with parent sensitivity and harsh-intrusion, given the significant role of parenting behavior in infants' early emotional functioning (Calkins, 1994; Sroufe, 1996).

Physiological Functioning and Emotion Reactivity and Regulation

Physiological activity is thought to be an important component of emotion and ER processes (Dennis et al., 2012). The body has two major stress response systems: the autonomic nervous system (ANS) and the Hypothalamic-Pituitary-Adrenal (HPA) Axis. These systems serve to maintain homeostasis and regulate various biological functions (e.g., cardiac activity, digestion, immune system, and energy storage & expenditure), as well as to biologically prepare the organism to respond cognitively and behaviorally to stressful, salient, and/or emotionally-laden situations (Porges, 1992; Gunnar & Quevedo, 2007). Whereas the ANS is considered the body's fast-acting stress response system, the HPA axis functions as the slow-acting stress response system (Shirtcliff et al., 2009). When experiencing stress, the hypothalamus releases corticotrophin releasing factor, stimulating the pituitary gland to release adrenal corticotropic hormone, which promotes the release of glucocorticoids, such as cortisol (Gunnar & Quevedo, 2007). The HPA axis responds to stressful stimuli in the order of minutes, as opposed to the immediate responses of ANS, meaning that HPA responses can have lasting effects on emotion functioning over minutes or hours (Sapolsky, Romero, & Munck, 2000).

Although the HPA axis is considered a key part of adaptive responding to stress in the short-term (Gunnar & Davis, 2003), its functioning is significantly affected by the presence of chronic stress. Persistent HPA activation, or allostatic load, can result from exposure to chronically stressful environments and may interfere with infants' and young children's ability deal with to effectively handle various challenges and regulate emotions (McEwen, 1998). It may also lead to both mental and physical health problems during childhood and adulthood (Evans, 2003, 2004; Gordis, Granger, Susman, & Trickett, 2008; McEwen & Seeman, 1999). Further, because chronic hyperarousal of cortisol is linked with damaging effects to neurological and physiological systems (Bremner & Vermetten, 2001; De Bellis & Kuchibhatla, 2006; McEwen & Wingfield, 2003; Raison & Miller, 2003; Sapolsky et al., 2000), allostatic load may lead to a downregulation of HPA activity and hypoarousal, in general and in response to stress (Gunnar & Vasquez, 2001; Susman, 2006). Such attenuation of HPA activity is thought to be adaptive, in that it protects the body from the "wear and tear" of high cortisol levels, but it may also interfere with children's ability to respond to challenge and regulate emotions by not allowing for a heightened physiological response when needed. Indeed, cortisol hypoarousal has been associated with poor self-regulation and behavior problems during childhood (Blair, Granger, & Razza, 2005; Gunnar & Vasquez, 2001) and antisocial behavior in adolescence and adulthood (Cima, Smeet, & Jelacic, 2008; Gostisha et al., 2014; Stadler et al., 2011).

Thus, physiological functioning, including cortisol activity, seems to play an important role in emotion and ER. Whereas physiological and behavioral aspects of emotion have previously been assumed to operate in synchrony (e.g., high behavioral reactivity accompanied by high cortisol reactivity), the current prevailing notion is that physiological responses reflect biomarkers that are correlated with experiences and expressions of emotions, but do not always act in tandem with them (Dennis et al., 2012; Gunnar & Davis, 2003). Lewis (2011) argues that synchrony and asynchrony of physiological and behavioral activity may both serve distinct and important functions, depending on the context in which emotions occur. For example, physiological responding without evidence of behavioral responding may reflect an ability to cognitively regulate emotion without outwardly expression of internally felt emotions (Fox et al., 2012), or emotional arousal and/or regulation occurring below the level of consciousness (Cole et al., 2004). Likewise, synchronous responses may even be reserved for highly salient or stressful circumstances, especially with respect to cortisol responses (Lewis, 2011). This is supported by evidence that cortisol responses require more physically, emotionally, or socially threatening to be activated, compared to ANS responses (Gunnar & Adam, 2012).

Empirical research has demonstrated inconsistent correlations and synchrony of behavioral and cortisol reactivity during infancy and early childhood. Lewis and colleagues conducted several studies of infants with mixed results ranging from no correlation to moderate correlations between the two (Lewis, 2011). For example, they found that cortisol and behavioral reactivity to inoculation among 6-month-olds were not correlated (Ramsey & Lewis, 2003). However, they also found that cortisol reactivity and sad expressions in response to a contingency learning goal-blockage task were positively correlated at 4 months old and 6 months old in a longitudinal sample, but the same was not true for cortisol and anger expressions (Lewis & Ramsey, 2005). Likewise, data from the current sample have shown inconsistent correlations at 6, 15, and 24 months old in response to scary mask, arm restraint, and toy barrier/removal tasks (Ursache et al., 2014). At 6 months, behavioral reactivity to the barrier task was associated with increases and subsequent decreases in cortisol reactivity (indicative of reacting, and then returning to baseline), but behavioral reactivity to the mask and arm restraint tasks were marginally correlated and not correlated, respectively, with cortisol reactivity. At 15 and 24 months, behavioral reactivity to the mask task was associated with increases and subsequent decreases in cortisol, whereas reactivity to the toy removal was not.

A handful of studies have also examined concurrent associations of physiological and behavioral reactivity with children's use of ER behaviors. In a study of two-year-old children, Mirabile and colleagues found that children's behavioral reactivity to arm restraint and waiting tasks was not related to their use of ER behaviors during the tasks (Mirabile, Scaramella, Sohr-Preston, & Robison, 2009). Among 3-year-old children, Zimmerman and Stansbury (2004) found that cortisol reactivity in response to a stranger approach was negatively associated with ER behaviors. Conversely, Calkins (1997) found that respiratory sinus arrhythmia (RSA) reactivity (an index of parasympathetic nervous system responding) was positively associated orienting toward an experimenter among 2-3-year-old children in response to barrier and delay tasks. However, RSA reactivity was not associated with orienting toward distressing stimuli, self-soothing, or orienting to non-task objects. In the current sample, increases in cortisol in response to the barrier task at 6 months were positively associated with ER behaviors, generally, but cortisol responses to the mask task were not. At 15 and 24 months, cortisol reactivity and

ER behaviors were not related (Ursache et al., 2014). These mixed findings across studies suggest that examining associations between variable-centered continuous measures of behavioral reactivity, physiological reactivity, and ER behaviors may not be adequate for capturing patterns of individual differences in children's emotional functioning. Rather, person-centered approaches may help to better describe and predict these responses, given the various reasons why physiological and behavioral responding may not match.

Using Latent Profile Analysis to Understand Biobehavioral Emotion Processes

Latent profile analysis (LPA) is a person-centered, data-driven approach that classifies individuals into profiles based on having similar scores on a set of indicators (Geiser, 2013). Using maximum likelihood estimation, this statistical method iteratively estimates individuals' probability of being in each potential profile using their scores on the indicators, and then assigns them to their most likely profile (Hagenaars & McCutcheon, 2002). It is particularly useful for evidencing individual differences in situations where there are multiple patterns of scores on indicators that are not reflected in the overall correlations between variables (Lanza, Tan, & Bray, 2013). Thus, LPA presents an innovative means for understanding how behavioral reactivity, physiological reactivity, and ER behaviors coact during infancy and early childhood by allowing for the detection of children's distinct patterns of arousal and regulation.

Although LPA has garnered increasing use across social sciences for modeling population heterogeneity (Nylund-Gibson & Masyn, 2016), only two studies (to my knowledge) have utilized the method for understanding biobehavioral emotion processes during infancy. In a recent study, Qu and Leerkes (2018) examined profiles of behavioral and RSA reactivity in response to the still-face paradigm (Tronick, Als, Adamson, Wise, & Brazelton, 1978) among 6-month-old infants. They found four biobehavioral profiles: (1) high negative reactivity and high RSA reactivity to the still-face episode with no recovery during reunion, (2) low negative reactivity and low RSA reactivity (but low baseline RSA), (3) low negative reactivity and low RSA reactivity (but high baseline RSA), and (4) high negative reactivity and low RSA reactivity. Since the shift from higher baseline RSA to lower RSA during challenge is considered to be the normative pattern of arousal (Porges, 1996), profiles 2 and 3 differed in that profile 2 characterized children who did not show RSA reactivity because they already demonstrated autonomic hyperarousal at baseline. Using the current sample, Towe-Goodman and colleagues examined profiles of behavioral and cortisol reactivity in response the previously mentioned emotion-eliciting challenge tasks at 6 months old (Towe-Goodman, Stifter, Mills-Koonce, Granger, & The Family Life Project Key Investigators, 2012). They found four profiles: (1) low behavioral and cortisol reactivity (with low baseline cortisol), (2) moderate behavioral reactivity and high cortisol reactivity, (3) high behavioral reactivity and low cortisol reactivity, and (4) low behavioral cortisol reactivity (with high baseline cortisol). Thus, both studies found distinct patterns of synchronous and asynchronous reactivity that may have different developmental origins, including normative baseline physiological arousal versus hyperarousal.

These studies have provided innovative looks into the match and mismatch of physiological and behavioral emotion reactivity, but they did not include concurrent ER behaviors as part of their profiles. Without the inclusion of ER behaviors, the relevance of reactivity to downstream functioning remains unclear. Individual differences in infants' ability to regulate their reactivity has been shown to predict positive outcomes, like academic achievement and school readiness, social skills and relationships, and adjustment (e.g., Blair et al., 2015; Bowie, 2010; Graziano & Garcia, 2016; McQuade & Breaux, 2017; Morrison et al., 2010; Sjöwall, Bohlin, Rydell, & Thorell, 2017). For example, an infant who shows high emotional reactivity to stress, but is able to use ER skills to help himself/herself calm down (e.g., looking away from stressful stimuli or self-soothing) likely has a qualitatively different experience than an infant who becomes equally aroused, but does not engage in regulatory behavior. The infant who is able to reduce arousal through ER behavior is more likely to be able to focus on learning and engaging with social others, rather than continuing focus on negative stressors, ultimately promoting positive development across functional domains. Therefore, the current study utilized LPA to examine patterns of reactivity and regulation, while also extending these profiles to 15 and 24 months of age in order to assess infants' change in emotion functioning over time. Measuring these patterns over time allows for the examination of developmental change in emotion functioning and its potential implications for later outcomes. For example, infants who show high reactivity and low ER early, but then develop better ER skills over time may show better later functioning than infants who show consistently high reactivity and low ER. Further, the developmental stability or change in these may reflect varied developmental histories of interactions with the environment. Therefore, I also examined the associations between infants' early environments and profiles of emotion functioning via proximal interactions with their parents throughout infancy.

Parent–Child Relationships and Biobehavioral Emotion Processes

Developing emotional competence in infancy and early childhood is influenced by numerous intra- (e.g., genetics, cognitive development) and extra-personal processes (e.g., environmental influences). Parents, in particular, embody the most proximal and potent environmental influence on development, particularly in early life (Bornstein, 2002). During infancy, parents are virtually solely responsible for regulating their infants' emotions through various behaviors, like physical soothing, feeding, and attention modulation, but infants become progressively more capable of ER on their own (Calkins, 2009; Calkins & Dollar, 2014; Sameroff, 2010). Through dyadic interactions with parents, infants learn ER behaviors by integrating into their own skill-set the behaviors used by parents to soothe them (Calkins & Hill, 2007; Sroufe, 1996). Multiple types of parenting behavior are key in influencing children's ER development over time (Eisenberg, Cumberland, & Spinrad, 1998; Morris, Silk, Steinberg, Myers, & Robinson, 2007). However, during infancy, arguably the strongest influence of parents is transmitted through sensitivity (and, conversely, insensitivity) and the formation of parent–infant attachments. Attachment theory posits that repeated experiences with parents over the course of infancy establish an affective bond that allows infants to use their parents for emotional support and as secure bases for exploration (Bowlby, 1969/1982). Further, the formation of this relationship contributes to children's ability to regulate emotions and provides expectations for future social interactions with parents and others (i.e., internal working models; Sroufe, 1996). Of course, repeated experiences of sensitive parenting are expected to promote the formation of secure attachments and better emerging ER abilities, whereas less sensitive parenting (e.g., detached and/or harsh and intrusive) are expected to promote insecure attachment and poorer ER (Calkins & Leerkes, 2004).

Parent sensitivity has been empirically linked with both ER and physiological responding in infancy and early childhood (see Calkins & Dollar, 2014 for a review). For example, Calkins and colleagues found that negative, punitive, and controlling behavior by mothers was positively associated with 24-month-old children's orientation toward and/or manipulating an object of frustration (considered to be less adaptive ER in the moment), and negatively associated with self-distracting ER behaviors (considered to be more adaptive in the moment; Calkins, Smith, Gill, & Johnson, 1998). Similarly, Feldman Dollberg, and Nadam (2011) found that maternal intrusiveness was positively associated with 2-3-year-old children's anger in response to a toy removal task and the still-face paradigm, but that maternal sensitivity was positively associated with their ER behavior during the still-face. Although not synonymous with sensitivity, parent–infant attachment can serve as a proxy of sensitivity, given the theoretical link between consistently sensitive caregiving and secure attachment. Notably, attachment security has been associated with both behavioral reactivity and ER behaviors (Leerkes & Wong, 2012; Sherman, Stupica, Dykas, Ramos-Marcuse, & Cassidy, 2013).

Evidence from both animal and human models has demonstrated effects of caregiving on cortisol functioning (Champagne et al, 2008; Liu, Diorio, Day, Francis, &

Meaney, 2000). Spangler and colleagues (1994) found that infants of mothers who displayed very low levels of sensitivity exhibited higher cortisol levels in response to a free-play session with their mother and a diaper change at 3 and 6 months, compared to infants of more sensitive mothers. Similarly, Grant and colleagues (2009) found that lower maternal sensitivity was associated with greater cortisol reactivity in response to the still-face among 7-month-old infants. Martinez-Torteya et al. (2015), on the other hand, examined links between mothers' intrusive and controlling behaviors and infants' cortisol responses to challenging tasks at 7 and 16 months (the still-face and strange situation procedures, respectively). Infants of mothers who exhibited higher levels of intrusive or controlling behaviors displayed higher levels of cortisol in response to the stress tasks at both ages, as well as higher levels of baseline cortisol. Consolidating the behavioral and physiological literatures, a recent study by Perry, Calkins, and Bell (2016) examined RSA reactivity as a mediator of prospective associations between maternal sensitivity at 5 months and ER behaviors in response to challenge at 10 months. They found that maternal sensitivity predicted infants' mother-orienting behaviors, mediated through their RSA reactivity. However, neither sensitivity nor RSA reactivity were associated with infants' self-distracting behaviors, further suggesting the utility of investigating the presence of distinct patterns of biobehavioral emotion responses.

Of course, parent–child relationships are not unidirectional, but rather infants play an active role in their development, and their emotion functioning has important influences on parents' behavior (Gottlieb, 2007; Sameroff, 2010). For example, extensive research has examined the effects of infants' temperamental reactivity (measures of which often encompass aspects of emotion reactivity and regulation) on parent sensitivity. The existing evidence has been mixed—some studies suggest that negative reactivity is negatively associated with parent sensitivity, other studies suggest negative reactivity is positively associated with parent sensitivity, and still others suggest no association whatsoever (e.g., Calkins, Hungerford, & Dedmon, 2004; Gudmundson & Leerkes, 2012; Kiss, Fechete, & Susa, 2014). Given the influence that infants can have on their parents, it is possible that observing distinct patterns of behavioral reactivity, physiological reactivity, and ER behaviors can better elucidate the effects of infants' emotions on parenting behavior.

Current Study

The current study used LPA to prospectively examine the synchrony and asynchrony of infant behavioral reactivity, cortisol reactivity, and ER behaviors at 6, 15, and 24 months of age determine whether groups of infants evidence different patterns of arousal and regulation. I hypothesized that there would be up to six biobehavioral profiles consistent across age: (1) low behavioral reactivity, low cortisol reactivity, and low ER behaviors (i.e., non-reactors); (2) high behavioral reactivity, high cortisol reactivity, and low ER behaviors (i.e., synchronous reactors); (3) high behavioral reactivity, low cortisol reactivity, and low ER behaviors (i.e., asynchronous reactors); (4) high behavioral reactivity, high cortisol reactivity, and high ER behaviors (i.e., synchronous regulators); (5) Moderate-to-high behavioral reactivity, low cortisol reactivity, and high ER behaviors (i.e., asynchronous regulators); and (6) low behavioral reactivity, high cortisol reactivity, and low-to-moderate ER behaviors (i.e., suppressors).

In addition, I assessed the stability and change in the resulting emotion profiles using latent transition analysis (LTA), which tests whether infants move from one profile to another over time (Lanza, Patrick, & Maggs, 2010). I hypothesized that infants would be most likely to transition out of the ‘synchronous reactors’ group between 6 and 24 months, and that infants would be most likely to transition into the ‘asynchronous regulator’, ‘synchronous regulator’, and ‘suppressor’ classes over time. Table 1 shows the expected levels of behavioral reactivity, cortisol reactivity, and ER behaviors in each emotion profile, as well as their expected likelihood at each age.

I also examined bidirectional, prospective associations of profile membership with parent sensitivity and harsh-intrusion across infancy (see Figure 1 for full conceptual model). I hypothesized that sensitivity would concurrently and prospectively predict greater likelihood of membership in profiles characterized by low reactivity (behavioral and/or cortisol) and/or high regulation, and lower likelihood of membership in profiles characterized by high reactivity and low regulation. Conversely, I expected to find the opposite pattern for parent harsh-intrusiveness. I also hypothesized that sensitivity and harsh-intrusion would be associated with higher and lower likelihood, respectively, of infants transitioning from profiles characterized by high reactivity (behavioral and/or cortisol) and low regulation into profiles characterized by low reactivity and/or high regulation.

With respect to infant effects on parenting, I hypothesized that membership in profiles characterized by high reactivity and low regulation would predict decreases in sensitivity and increases in harsh-intrusion over time. Conversely, I expected that membership in profiles characterized by low reactivity and/or high regulation would predict increases in sensitivity, and decreases in harsh-intrusion over time.

Methods

Participants

The Family Life Project is a large longitudinal study of children and families living in nonurban, low-income communities in the United States. Families and their newborns that lived in two major geographical areas of high child rural poverty (including three counties in eastern North Carolina and three counties in central Pennsylvania) were recruited using a stratified random sampling procedure, yielding a representative sample of 1,292 families recruited over a one-year period at the time mothers gave birth to a child. The sample was recruited to be representative of every baby born to an English-speaking mother living in the counties selected during the year of recruitment, while also oversampling for poverty and race (i.e., African American). The full sample included 549 African American (42.5%) children, 736 European American (57%) children, 7 children of other race (0.5%), 657 girls (50.9%), and 635 boys (49.1%). See Willoughby and colleagues (2013) and Garrett-Peters and Mills-Koonce (2013) for more information on the recruitment of the Family Life Project sample. Full-information maximum likelihood (FIML) estimation was used to account for missing data.

Procedures

Infants and families were visited for in-home data collection when the infants were 6, 15, and 24 months old. At each visit, primary caregivers (99.6% biological mothers at 2 months) completed demographic questionnaires, infants participated in a series of emotionally arousing challenge tasks, and parent–infant dyads completed a semi-structured play interaction together. The challenge tasks included a scary mask task, an arm restraint task, and a barrier tasks at 6 months. At 15 and 24 months, they completed the mask task and a toy removal task (Goldsmith & Rothbart, 1996). At 6 months, the mask task preceded the barrier and arm restraint tasks, and at 15 and 24 months the mask task followed the toy removal task. The current study used data from the arm restraint at 6 months and the mask task at 15 and 24 months because they both index fear reactivity, elicited the highest negative reactivity (on average), and coincided with most children's peak reactivity in response to the challenge tasks (Ursache et al., 2014).

In the mask task, four different masks were presented to the infant, one at a time. The experimenter wearing the mask moved from side to side in front of the infant for 10 seconds while saying the infant's name. The primary caregiver was present in the room during the mask task, but did not interact with the child. In the arm restraint task, the experimenter restrained the infant's arms at his/her side for 2 minutes. The infant's arms were then released for 1 minute, after which the primary caregiver was allowed to soothe the infant for 2 minutes. These tasks were video-recorded and coded second-by-second for infant reactivity and ER behaviors.

Three saliva samples were collected from infants in order to assess cortisol response to the emotionally arousing tasks. The first sample was a baseline sample collected before the tasks began, but after the researcher had been at the family's house for 1 hour. The second sample was collected approximately 20 minutes after the infant reached peak behavioral arousal, which was determined by the data collectors using clear guidelines established in the experimental protocol. Peak arousal for the vast majority of infants occurred at the conclusion of the emotional challenge tasks. Children who became highly aroused during the course of task administration as indicated by 20 seconds of hard crying, and who were determined to be too aroused for further task administration, were considered to have reached peak arousal. The third sample was collected 40 minutes after peak arousal. Unstimulated whole saliva was collected by using either cotton or hydrocellulose absorbent material and expressing the sample into 2 ml cryogenic storage vials using a needleless syringe (cotton) or by centrifugation (hydrocellulose). Two prior studies have indicated no differences in cortisol concentrations associated with the two collection techniques (Granger, Kivlighan, Fortunato, Harmon, Hibel, Schwartz, & Whembolua, 2007; Harmon, Granger, Hibel, & Rumyantseva, 2007). After collection, samples were immediately placed on ice, transported to interviewer's homes, and then stored frozen (–20°C).

For the parent–infant interaction at the 6- and 15-month home visits, primary caregivers and children were asked to play together as they normally would whenever they had free time during the day. Families were provided with a standardized set of developmentally appropriate toys and video recorded for 10 minutes and later coded for parenting behaviors. At the 24 months, parents and children were asked to complete a 10-minute puzzle task that consisted of three puzzles of increasing difficulty. Parents were instructed that the task was for the child to complete, but they could help as needed. The interaction was video-recorded and later coded for parenting behaviors.

Measures

Negative behavioral reactivity. Reactivity was coded second-by-second from video-recordings of the mask and arm restraint tasks for the total duration of the tasks and reactivity was coded separately for each. Three levels of negative emotional reactivity were coded: low reactivity including behaviors such as fussing, whining, frowning, furrowed brow, crinkled nose, slightly open or pressed lips; medium reactivity including crying, wide squared mouth, and eyes open or partially opened; and high reactivity including screams, wails, eyes partially or completely closed, and wide open mouth. Coders were trained to achieve .75 (Cohen's K) reliability. Interrater reliability for each task was calculated on at least 15% of cases at each visit. Interrater reliability was high for the mask task at 6, 15, and 24 months (K = .95, .89, and .90, respectively), and was moderately high for the arm restraint task at 6 months (K = .85). The proportion of time the child spent in mild, moderate, and highly negative reactive states during each task was calculated by dividing the number of seconds for each code by the total task duration. A mean intensity of negative reactivity score was calculated for each task by multiplying the proportion of time the child spent in mild, moderate, and highly reactive states by 1, 2, and 3, respectively, then calculating a mean of those weighted intensity scores (Towe-Goodman et al., 2012).

Emotion regulation behaviors. Emotion Regulation behaviors were coded second-by-second from video-recordings of each task by a separate team of coders.

Specific behavioral codes were separated into three categories of non-overlapping ER strategies, based on past research (see Stifter & Braungart, 1995): (1) orienting regulation, which included the specific behaviors of orienting to the environment and looking to mother; (2) soothing/communication regulation, which included self-comforting, neutral vocalizations, gesture, and seeking comfort/contact; and (3) avoidance/active regulation, which included avoidance, tension reduction, and rejection. Within each category, only one specific behavior could be coded for at each second. Because a child could perform behaviors from multiple categories at the same time, however, each category was coded for by a separate team of coders. Thus, for each second of video, it was possible to have three regulation codes, but only one from each category. While all three categories were coded at each age, some of the specific regulation behaviors within categories were only coded later time points, in accordance with infant development and emergent skills (e.g., language acquisition and increased complexity of cognition).

Coders were trained to .75 (Cohen's K) reliability. Interrater reliability for each task was calculated on at least 15% of cases at each visit. For the mask tasks at 7, 15, and 24 months, reliability ranged .95–.99, .97–.97, and .92–.97, respectively, across categories of regulatory behaviors. Reliability for the arm restraint task ranged from .82 to .93 across the categories of regulatory behaviors. The proportion of time spent using each of these behaviors was calculated as the number of seconds for a specific behavior divided by the total duration of the task. The ER behavior variable for the current study represents the proportion of time that infants used regulatory behaviors during the task and was created by summing the proportion of time spent using each of the regulatory behaviors.

Salivary cortisol reactivity. Unstimulated whole saliva was collected by using either cotton or hydrocellulose absorbent material and expressing the sample into 2-ml cryogenic storage vials using a needleless syringe (cotton) or by centrifugation (hydrocellulose). All samples were assayed for salivary cortisol with a highly sensitive enzyme immunoassay (Salimetrics, State College, PA) that has been U.S. Food and Drug Administration 510(k) cleared for use as an in vitro diagnostic measure of adrenal function. The test used 25 μl of saliva (for singlet determinations), had a range of sensitivity from 0.007 to 1.8 g/dl, and had average intra- and interassay coefficients of variation of <10% and 15%, respectively. All samples were assayed in duplicate. The criterion for repeat testing was variation between duplicates >20%, and the average of the duplicates was used in all analyses. Natural log transformations were applied to the cortisol values to correct for positive skew. Values >3 SD above and below the mean were removed as outliers. Cortisol reactivity levels were calculated by subtracting the pre-task levels from the 20-minute post-peak arousal levels.

Parent sensitivity and harsh-intrusive behaviors. The 10-minute, video-recorded parent–child interactions at 6, 15, and 24 months were observed by trained and reliable coders and rated globally on the following dimensions of parenting behavior: sensitivity, detachment, intrusiveness, stimulation, positive regard, negative regard, and animation (Cox & Crnic, 2002; see also NICHD Early Child Care Research Network, 1999). Coders gave a single rating for each code based on the overall quality of the entire interaction using Likert-type scales. Ratings ranged from 1 (not at all characteristic) to 5 (highly characteristic) at the 6- and 15-month assessments, and from 1 to 7 at the 24-month assessment (the latter scores were rescaled to a 1–5 range for the current analyses). At least 30% of all interactions at each assessment were double coded for reliability and interrater differences in scores were conferenced to create a final score for double-coded videos. Reliability was calculated using the intraclass correlation for the independent ratings made for the overlapping coding assignments. Reliability across subscales and composites was high (intraclass correlations > .80 for all subscales). Factor analyses guided the creation of a sensitive parenting composite and a harsh–intrusive parenting composite at each time point. Sensitive parenting was composed of the mean of sensitivity (level of responsiveness and support offered to the child contingent on the child's needs), positive regard (positive feelings and warmth directed toward the child), stimulation (developmentally appropriate language use), animation (level of facial and tonal affect), and detachment (reverse scored; degree to which the parent is disengaged). Harsh-intrusive parenting was composed of the mean of intrusiveness (controlling, parent-agenda driven behaviors) and negative regard (hostile verbal and physical treatment of the child). For more detailed information on the factor analyses of these variables, see Mills-Koonce et al. (2011).

Covariates. Child gender, child race, and primary caregivers' years of education were reported by primary caregivers when they were recruited at the time of their child's birth (and confirmed at each home visit). Family income-to-needs ratio (total household income divided by the 2005 federal poverty threshold) was reported by primary caregivers when children were 6, 15, and 24 months old; the mean income-to-needs ratio across these visits was used for the current analyses. The time of day at which children provided baseline saliva samples at each visit was recorded in order to account for variations in cortisol that may be the result of diurnal rhythms (Gunnar & Adam, 2012).

Analysis Plan

Latent profile analysis were used to identify groups of infants with similar patterns of behavioral reactivity, cortisol reactivity, and ER behaviors in response to the challenge tasks at each time point. Individual LPAs were conducted for each time point to determine whether patterns of reactivity and regulation change developmentally. All models were fit using Mplus 8 (Muthén & Muthén, 1998–2017). Missing data were handled using full information maximum likelihood methods (Enders & Bandalos, 2001). Given the stratified random sampling design, the robust maximum likelihood estimator (MLR) was used to estimate all models to allow for inclusion of individual probability weights associated with oversampling of low-income and African American families and stratification on income, state, and race. The optimal number of classes was determined based on a balance of theory, interpretability, and model fit using the Bayesian information criteria (BIC), sample size-adjusted Bayesian information criteria (ssBIC), and adjusted Vuong-Lo-Mendell-Rubin likelihood ratio test (aVLMR; Henson, Reise, & Kim, 2007; Nylund, Asparouhov, & Muthén, 2007). The class enumeration process was conducted using an unconditional model, in which no covariates were included. This allowed for the observation of various trajectories “in-vivo” without covariates impacting the optimal number of classes or children's class membership (Nylund-Gibson & Maysn, 2016).

Next, a LTA was conducted to examine whether infants patterns of arousal and regulation changed over time. Latent transition analysis is a latent variable method similar to logistic regression that allows for the assessment of longitudinal associations between multiple cross-sectional LPAs (Lanza et al., 2010). Using LTA enables the prediction of the likelihood of membership in each emotion profile at 15 months from profile membership at 6 months, and the profile membership at 24 months from membership at both 6 and 15 months. After assessing profile transitions using an unconditional LTA model, I tested a conditional model that included the additional predictors and covariates of interest, including parent sensitivity and harsh-intrusion. This conditional model allowed me to examine bidirectional, prospective associations between parenting behavior and emotion profile membership.

Results

Descriptive Statistics

Table 2 presents the bivariate correlations among the central study variables and covariates, as well as the means and standard deviations of each variable. Behavioral reactivity at 15-months was moderately positively correlated with behavioral reactivity at 24 months, but 6-month behavioral reactivity was not significantly correlated with either. Similarly, 15-month and 24-month cortisol reactivity showed a small positive correlation, but 6-month cortisol reactivity was not significantly correlated with either. The same pattern of association was found for ER, with 6-month and 15-month ER showing a small positive correlation, and 6-month ER showing no correlation with either. At 6 months, behavioral reactivity showed a small positive correlation with cortisol reactivity and a small negative correlation with ER, but cortisol reactivity and ER were not correlated. At 15 months, behavioral reactivity showed small-to-moderate positive correlations with cortisol reactivity and ER, but cortisol reactivity and ER were not correlated. At 24 months, behavioral reactivity showed a small-to-moderate positive correlation with cortisol reactivity and a moderate positive correlation with ER, and cortisol reactivity and ER showed a small positive correlation.

Regarding correlations with parenting, 6-month behavioral reactivity showed small negative correlations with harsh-intrusion at 6, 15, and 24 months, as well as a small positive correlation with 15-month harsh-intrusion. Cortisol reactivity at 6 months showed a small positive correlation with 15-month sensitivity, but showed no other significant correlations with parenting. Six-month ER was not correlated with either sensitivity or harsh-intrusion at any age. Behavioral reactivity at 15 months showed small positive correlations with harsh-intrusion at 6 and 15 months. Cortisol reactivity at 15 months showed small positive and small negative correlations with 24-month sensitivity and harsh-intrusion, respectively. Fifteen-month ER showed a small positive correlation with 15-month sensitivity. Behavioral reactivity at 24 months showed small negative correlations with sensitivity at 15 and 24 months, as well as small positive correlations with harsh-intrusion at 6, 15, and 24 months. Cortisol reactivity showed small negative and small positive correlations with 15-month sensitivity and harsh-intrusion, respectively. Finally, 24-month ER showed a small positive association with 6-month harsh-intrusion.

Latent Profile Analyses

Class enumeration. First, unconditional LPA models were analyzed at each age to determine the optimal number of classes. Models that included between 2-7 classes were tested. Table 3 presents the fit statistics for each model at 6, 15 and 24 months. Based on theory, interpretability, and fit statistics, the 4-class model was selected as the best-fitting model at 6 months. The 3-class model provided a parsimonious solution, but the 4-class model showed much better fit and still provided theoretically meaningful, interpretable, and parsimonious results.

At 15 months, the 5-class model selected as the best-fitting. Although the aVLMR suggested retaining the 4-class model, the BIC and ssBIC suggested that the 5-class model fit much better than the 4-class model. In addition, the 5-class model provided more theoretically interpretable and meaningful groups.

At 24 months, the 4-class model was selected as the best-fitting. The BIC and ssBIC suggested that the 5-class model had better fit, but the aVLMR suggested retaining the 4-class model. Further, the 4-class model was retained because it provided more theoretically interpretable and meaningful groups than the 5-class model.

6-month class descriptions. Figure 2 illustrates the patterns of behavioral reactivity, cortisol reactivity, and ER across the four classes. Notably, the four groups showed minimal differences in their levels of ER, which were all moderately high. Thus, the groups were distinguished by their patterns of behavioral and cortisol reactivity. Over half the sample (57.2%) was comprised by the most prevalent group, labeled the 'non-reactors' group, which was characterized by low behavioral reactivity (m = .04; SE = .004), low cortisol reactivity (m = .07), and moderately high ER (m = .51). The second most prevalent group (20.3%), labeled the 'moderate asynchronous regulators' group, was characterized by high behavioral reactivity (m = .47), moderately low cortisol reactivity (m = .11), and moderately high ER (m = .47). The third most prevalent group (15%), labeled the 'asynchronous regulators' group, was characterized by moderate behavioral reactivity (m = .26), low cortisol reactivity (m = -.01), and moderately high ER (m = .53). The final group (7.5%), labeled the 'synchronous regulators' group, was characterized by high behavioral reactivity (m = .66), high cortisol reactivity (m = .50), and moderately high ER (m = .41).

15-month class descriptions. Figure 3 illustrates the patterns of reactivity and regulation across the five classes. The most prevalent class (61.7%), labeled the 'non-reactors' group, was characterized by low behavioral reactivity (m = .08), low cortisol reactivity (m = .09), and low ER (m = .09). The second most prevalent class (16.9%), labeled the 'synchronous reactors' group, was characterized by high behavioral reactivity (m = .45), high cortisol reactivity (m = 43), and moderately low ER (m = .14). The third most prevalent group (11.2%), labeled the 'moderate synchronous regulators' group, was characterized by moderate behavioral reactivity (m = .18), moderate cortisol reactivity (m = .24), and moderately high ER (m = .46). The fourth most prevalent group (7.3%), labeled the 'synchronous regulators' group, was characterized by high behavioral reactivity (m = .56), high cortisol reactivity (m = .39), and high ER (m = .62). The final group (2.8%), labeled the 'low reactive regulators' group, was characterized by low behavioral reactivity (m = .10), low/decreasing cortisol reactivity (m = -.13), and the highest ER of all groups (m = .90).

24-month class descriptions. Figure 4 illustrates the patterns of reactivity and regulation across the four classes. Notably, ER was high among all four groups at 24 months, relative to 6 and 15 months; but there were some notable group differences in ER, unlike at 6 months. The most prevalent group (64.8%), labeled the 'non-reactors' group, was characterized by low behavioral reactivity (m = .04), low/decreasing cortisol reactivity (m = -.16), and moderate ER (m = .40). The second most prevalent group (13.4%), labeled the 'moderate asynchronous regulators' group, was characterized by high behavioral reactivity (m = .54), moderately low cortisol reactivity (m = .14), and high ER (m = .71). The third most prevalent group (12.6%), labeled the 'asynchronous regulators' group, was characterized by moderate behavioral reactivity, low/decreasing cortisol reactivity (m = -.10), and high ER (m = .73). The final group (9.2%), labeled the 'synchronous regulators' group, was characterized by high behavioral reactivity (m = .78), high cortisol reactivity (m = .39), and high ER (m = .85).

Taken together, the LPA results across age demonstrated partial support for the hypothesized patterns of reactivity and regulation. Table 4 presents a comparison of the hypothesized profiles with those that were found in the estimated models. Four of the six hypothesized emotion profiles were found, but the presence of each group was inconsistent across age. The 'non-reactors' group was found at all three ages, but infants in this group showed moderate, rather than low, ER at 6 and 24 months. The ‘synchronous regulators’ group was also found at all ages, but at 6 months, ER was only moderately high. Unexpectedly, two groups of ‘asynchronous regulators’ were found at 6 and 24 months: one with moderate behavioral reactivity, low cortisol reactivity, and high ER (asynchronous regulators); and the other with somewhat higher behavioral and cortisol reactivity compared to the other (moderate asynchronous regulators). Another unexpected group found at 15 months was the ‘low reactive regulators’ group, which showed low behavioral reactivity and cortisol reactivity, but very high ER—an interesting response pattern, given that ER would be expected in the presence of some form of reactivity. Finally, the hypothesized ‘asynchronous reactors’ and ‘suppressors’ groups were not found at any age. Although the LPA hypotheses only partially supported, the resulting groups enabled the assessment of developmental transitions among groups and bidirectional associations between the emotion profiles and parenting behavior over time.

Latent Transition Analysis

Unconditional model. Before examining the longitudinal associations between the estimated emotion profiles and parent sensitivity and harsh-intrusion, an unconditional LTA model was fitted to assess the transition probabilities of each of the emotion profiles. Table 5 presents the transition probabilities for each group at 6 and 15 months old. All 4 groups of infants at 6 months were most likely to be in the ‘non-reactors’ group at 15 months and the ‘synchronous regulators’ group at 24 months. Similarly, four of the five groups at 15 months—the ‘non-reactors’, ‘synchronous reactors’, ‘moderate synchronous reactors’, and ‘low reactive regulators’—were most likely to transition into the ‘non-reactors’ group at 24 months. The ‘synchronous regulators’ group at 15 months was most likely remain in the ‘synchronous regulators’ group at 24 months. The most common transition pattern that infants followed (30.2% of the sample) from 6 to 24 months was to remain in the ‘non-reactors’ group at all three time points. The second most common transition pattern (8.8%) was to move from the ‘moderate asynchronous regulators’ group at 6 months to the ‘non-reactors’ group at 15 months, and remain in the ‘non-reactors’ group at 24 months.

Conditional model with parenting and covariates. After estimating the unconditional model, a conditional LTA model was then estimated to assess the presence bidirectional effects between the emotion profiles and parent sensitivity and harsh-intrusion from 6 to 24 months, while controlling for covariates (as depicted in Figure 1). These bidirectional effects were modeled simultaneously, and included autoregressive effects in order to examine the influence of parenting behavior on change in the emotion profiles over time, and vice versa. Given that the conditional LTA model included endogenous nominal latent variables and continuous observed variables, all of which had some missing data, Monte Carlo integration was required to conduct the analysis. Monte Carlo integration is a simulation-based estimation approach that enables the analysis of complex models (Skrondal & Rabe-Hesketh, 2004). However, it is computationally intensive and, in the current application, it required very heavy calculations (8 dimensions of integration, 5000 points of integration) that significantly increased the amount of time needed to estimate the models.

In order to reduce the computational load, a subset of group comparisons were selected for the effects of parent sensitivity and harsh-intrusion on 15- and 24-month emotion profile membership, rather than testing all pairwise comparisons. At all ages, 'non-reactor' and 'synchronous regulators' groups were identified, and these two groups represented the highest and lowest values of behavioral reactivity, cortisol reactivity, and ER, respectively. Thus, these two profiles as reference groups when assessing parenting effects. In addition, the heavy computational load of the analysis prevented me from testing the effects of parenting behavior on the infants' transition probabilities, meaning that parenting effects on probability of profile membership were tested, but parenting effects on the likelihood of moving prospectively from one profile to another were not.

On the other hand, the estimation of effects of emotion profile membership on parent sensitivity and harsh-intrusion required the use of the Wald test of parameter constraints (Cox & Hinkley, 1974), which allows for the inclusion of all pairwise comparisons without increasing computational load. Therefore, all pairwise comparisons of emotion profile group membership were analyzed for longitudinal prediction of parenting behavior.

Longitudinal parenting effects on emotion profile membership. Table 6 presents the estimates of parenting effects on emotion profile membership at 15- and 24-months old. Parent harsh-intrusion at 6 months was associated with a greater likelihood of membership in the 'synchronous regulators' group compared to the 'non-reactors' and 'moderate synchronous regulators' groups at 15 months. A one-point increase in harsh-intrusion (on a 5-point scale) was associated with 69% increase in the likelihood of being in the ‘synchronous regulators’ group versus the ‘non-reactors’ group. By extension, infants’ whose primary caregivers showed the most harsh-intrusion at 6 months were 3.72 times more likely to be in that group than those whose primary caregivers showed minimal harsh-intrusion at 6 months. Likewise, a one point increase in harsh-intrusion at 6 months was associated with a 227% increase in the likelihood of ‘synchronous regulators’ membership versus ‘moderate synchronous regulators’ membership at 15 months; and infants whose primary caregivers showed the most harsh-intrusion were 9.09 times more likely to be in the ‘synchronous regulators’ group than those whose primary caregivers showed minimal harsh-intrusion. Parent sensitivity and harsh-intrusion at 6 months did not predict any other emotion profile differences at 15 months. Further, neither sensitivity nor harsh-intrusion at 6 or 15 months predicted any differences in emotion profile membership at 24 months.

Longitudinal emotion profile effects on parenting behavior. Table 7 presents the estimates of emotion profile group membership effects on parenting behavior at 15 and 24 months old. The current version of Mplus does not allow values of distal outcomes (parenting behavior, in this case) to vary across levels of multiple categorical variables. Therefore, I was unable to test the influence of 6-month emotion profile membership on 24-month parenting behavior, but I was able to examine effects from 6 to 15 months, and from 15 to 24 months. Results indicated that infants in the ‘synchronous regulators’ group at 6 months had parents who showed higher sensitivity and lower harsh-intrusion at 15 months than infants in the ‘non-reactors’, ‘asynchronous regulators’, and ‘moderate asynchronous regulators’ groups. No other 6m group differences were predictive of 15 month parenting behavior. Emotion profile membership at 15 months did not significantly predict differences in parent sensitivity or parent harsh-intrusion at 24 months.

Discussion

The current study had two major goals: (1) to examine whether heterogeneous patterns of behavioral reactivity, cortisol reactivity, and ER in response to emotionally arousing stimuli could be modeled across infancy and (2) to examine bidirectional, prospective associations between such differential patterns and early parenting behavior. Regarding the first stated goal, results were partially consistent with expectations. Across time points, four of the six expected patterns of reactivity and regulation were found. However, some of these groups were found inconsistently across age. For example, the 'synchronous reactors' group was only found at 15 months and the 'asynchronous regulators' group was only found at 6 and 24 months. Further, I found three unexpected groups that reflected either more extreme or more moderate versions of the hypothesized groups: moderate asynchronous regulators (at 6 and 24 months), moderate synchronous regulators at (15 months only), and low reactive regulators (at 15 months only). Finally, the groups found did not always perfectly fit their expected patterns of behavior. For example, all groups at 6 months showed moderate ER, meaning the 'non-reactors' group showed moderate ER, rather low ER. Likewise, the 'non-reactors' group at 24 months showed moderate ER, but the ER level for that group was the lowest of all groups at that age.

Despite some inconsistencies with expectations, the profiles found make theoretical sense, with some children showing high behavioral and physiological reactivity paired with ER attempts; others that responded with behavioral reactivity to the challenge tasks and ER attempts, but did not experience enough threat to engage the HPA axis; and others that did not respond with behavioral reactivity to challenge and were able to use ER behaviors to maintain a calm state, if needed. In addition, these results indicate that LPA can be used to model heterogeneity in patterns of emotion reactivity and regulation during infancy. Further, results from the LTA showed that infants were most likely to remain in, or transition to, the 'non-reactors' group over time, demonstrating the ability to model developmental change in emotion responding.

Utility of Person-Centered Approaches Assessing Heterogeneity in Emotion Responding

Person-centered approaches are particularly suited for examining functioning in circumstances in which single variables or correlations cannot adequately reflect real-world complexity or variation. Inconsistent associations in previous research suggest that biobehavioral emotion functioning is a phenomenon that can be better understood through such an approach. The current study extends the small existing literature that has used person-centered approaches to assess emotion functioning in infancy by examining joint patterns of behavioral reactivity, cortisol reactivity, and ER behaviors; and by observing these patterns at multiple points throughout infancy. Taken together, my findings provide further support for the utility of LPA for understanding these interrelated aspects of emotion functioning. Importantly, infants showed differential patterns of reactivity and regulation at each time point. Although some profiles showed similar response patterns that differed only in degree of response (e.g., asynchronous regulators vs. moderate asynchronous regulators), others showed distinctly different patterns of response that would not be observable when examining behavioral reactivity, cortisol reactivity, and ER independently (e.g., non-reactors vs. synchronous reactors vs. asynchronous regulators, etc.). Moreover, the patterns of behavioral and cortisol reactivity in the groups found were relatively consistent with the profiles found in previous studies (i.e., Qu & Leerkes, 2018; Towe-Goodman et al., 2012).

The addition of ER as an indicator in the LPA enabled the consideration of a dimension of emotion functioning not included in previous studies. Rather than solely examining the match and mismatch of behavioral and physiological reactivity, I was able to observe the pairing of reactivity with attempts to regulate arousal. Although most of the groups, across age, showed at least moderate ER attempts, ER at 15 and 24 months distinguished groups of infants that likely would have clustered together if ER had not been included (e.g., synchronous regulators vs. synchronous reactors; non-reactors vs. moderate asynchronous reactors. This addition demonstrates the flexibility of LPA, which can handle the inclusion of several observed indicators, and even improve estimation with increases in the number of indicators (Wurpst & Geiser, 2014). Early emotion functioning, then, can be examined in various ways with different potential indicators. For example, future studies could use LPA to model the synchrony of multiple aspects of physiological responding, such as HPA axis, sympathetic nervous system, and parasympathetic nervous system reactivity, given that the interaction of these physiological systems is still not well understood (Dennis et al., 2012).

Importantly, the inclusion of indicators should be done with interpretability as a priority because higher numbers of indicators significantly increases the potential number of profiles one might theoretically expect. In the current study with three indicators, I hypothesized six possible patterns of emotion responding, but there were certainly others that could have reasonably been proposed (e.g., low behavioral reactivity, high cortisol reactivity, high ER). Thus, LPA can be used to better understand complexity, but requires some simplification in order to maintain feasibility. For example, I utilized a difference score between baseline and post-challenge task to represent cortisol reactivity. Although modeling cortisol reactivity using growth curve models is preferable (Gunnar & Adam, 2012), doing so would not be feasible in a LPA framework. Likewise, area under the curve analyses allow for the consideration of multiple post-challenge values of cortisol (Fekedulegn et al., 2007), but cannot distinguish between certain patterns of cortisol response, such as high initial reactivity with moderate recovery and moderate reactivity with little recovery. With respect to ER measurement, I did not distinguish between different types of ER behavior in order to maintain parsimony. However, a LPA of ER, in particular, could be used to investigate whether individual behaviors or combinations of behavior are more or less adaptive.

In addition to the within-time variation modeled through LPA, the LTA approach enabled to the modeling of developmental change in infants' biobehavioral patterns of response to emotion-eliciting stimuli. Infants were most likely to remain in, or transition into, the ‘non-reactors’ group from 6 to 24 months, with the exception of infants in the ‘synchronous regulators’ group at 15 months, who were most likely to remain in the same group at 24 months. These results suggest that most infants gained experience in their environments and/or ER skills over time that enabled them to become less reactive to the challenge tasks. Infants still in the ‘synchronous regulators’ group at 15 months, however, may not have developed the skills to properly regulate stressful stimuli, possibly placing them on a trajectory of continued high reactivity. Although variable-centered approaches do allow for the assessment of developmental change, they cannot do so for differing patterns of multiple variables, unless groups are created manually; and creating groups manually relies solely on theoretical bases. The advantage of LTA, then, is that it examines developmental change in empirically-derived groups, rather than of groups that may or may not exist in the data. However, this advantage needs to be balanced against the possibility that a LPA may not have the power to detect small groups that differ from the rest of the sample because they are likely to get placed in the larger groups driving the results.

As with any methodology, person-centered approaches have their strengths and limitations. Although they require certain tradeoffs, LPA and LTA clearly enable a unique understanding of emotion responding across multiple levels of analysis. The current findings offer insights into the relation between reactivity and regulation that are not accessible through variable-centered analyses. Further, LPA and LTA are tools that can be used in future research to examine other aspects of emotion functioning not assessed here.

Bidirectional Prediction of Parenting Behavior and Emotion Responding

With respect to the second stated goal of the study, there was partial support for hypotheses, in that there were bidirectional associations between infants' emotion profile membership and parenting behavior, but these associations were limited and inconsistent across age. Specifically, parent harsh-intrusion at 6 months predicted a greater likelihood of infants being in the 'synchronous regulators' group at 15 months, relative to the 'non-reactors' and 'moderate synchronous regulators' groups. These results were somewhat consistent with hypotheses, which were that parent sensitivity and harsh-intrusion would predict greater and lesser likelihood, respectively, of membership in profiles characterized by low reactivity and high regulation. The 'synchronous regulators' group generally showed the highest scores across all indicators, suggesting they had the most difficulty regulating their emotions, despite spending the most time attempting to do so. Thus, it seems that harsh-intrusive parenting at 6 months may have increased infants' reactivity during stress and decreased their ability to self-soothe, consistent with previous research (Dollberg & Nadam, 2011). Alternatively, harsh-intrusive parenting may have increased infants' reactivity so much that even effective ER efforts were not enough to reduce their reactivity to levels similar to those of infants in the other groups. A lack of parenting effects on 24-month emotion responding may suggest that the negative effects of harsh-intrusive parenting may have already been consolidated by 15 months old.

Conversely, membership in the 'synchronous regulators' group at 6 months, relative to the 'non-reactors' group, was associated with higher parent sensitivity and lower parent harsh-intrusion from 6 to 15 months. The same was true of the ‘synchronous regulators’ group versus the ‘asynchronous regulators’ group. These findings contradicted expectations. Rather than discouraging sensitivity and encouraging harsh-intrusion from parents, the seemingly dysregulated nature of the ‘synchronous regulators’ group seems to have elicited sensitivity and discouraged harsh-intrusive behavior. This is consistent with previous research suggesting that infant dysregulation can serve as a signal to parents that more support is needed, resulting in greater warmth and responsiveness. However, the literature on such child effects are mixed, and it is important for future investigations to examine potential moderators, such as parent stress, that may lead parents to respond one way or another to infants’ dysregulation (Kiss et al., 2014). Given that many infants in the sample still fit profiles characterized by moderate to high behavioral and cortisol reactivity, examining potential moderators may also be useful in understanding why emotion responding at 15 months did not predict parenting behavior at 24 months.

Harsh-Intrusion and the Synchronous Regulators Profile

Taken together, the findings from the current study suggest that there may be a unique developmental process involving harsh-intrusive parenting and the ‘synchronous regulators’ group. Again, harsh-intrusion at 6 months predicted greater likelihood of membership in the ‘synchronous regulators’ group and, conversely, membership in the ‘synchronous regulators’ group at 6 months predicted less harsh-intrusion and more sensitivity. However, neither parent nor infant effects were present from 15 to 24 months. Further, the most likely group that 6-month ‘synchronous regulators’ transitioned into at 15 months was the ‘non-reactors’ group, but 15-month ‘synchronous regulators' were most likely to remain in that group at 24 months. This pattern of findings indicates that the emotion responses of infants in the 'synchronous regulators' group at 6 months may have been driven by genetic, temperamental, and/or unobserved early experiential influences (Calkins, 2009; Rothbart, Posner, & Kieras, 2006), but that their high reactivity prompted parents to engage in more sensitive and less harsh-intrusive parenting. These improvements in parenting, then, may have increased the likelihood that infants transitioned out of the 'synchronous regulators' group. On the other hand, harsh-intrusion at 6 months promoted membership in the 'synchronous regulators group', potentially leading some infants to remain stable in that group and prompting others to transition into it. Thus, the 'synchronous regulators' group may reflect two largely distinct, but partially overlapping, groups of infants over time: (1) 6-month-old infants who elicit better parenting and transition out due to improvements in parenting, and (2) 15-month-old infants who either remain in the group or transition into it because of harsh-intrusive parenting at 6 months, and then are likely to remain in the group at 24 months.

Importantly, the inability to test the effects parenting behavior on transition probabilities means that this proposed bidirectional cascades is merely speculative. Nevertheless, the combination of parent and child effects seem to indicate that infants' emotion responses are malleable at 6 months and become consolidated over time, dependent on parenting behavior during the same period. If this developmental cascade is, indeed, an accurate portrayal of the parent and child influences, then it lends itself to potential intervention efforts. Specifically, young infants who show high reactivity paired with ineffective regulatory efforts (or, at least, not fully effective efforts) may benefit from parenting interventions that help parents respond sensitively to their infants' distress, such as the Attachment and Biobehavioral Catchup (Dozier, Lindheim, & Ackerman, 2005).

Strengths and Limitations

The current study benefited from at least four notable strengths. First, observational methods were used to measure of behavioral reactivity, ER, and parenting behavior, as opposed to parent reports. These measures reduced the potential for error due to parents' potential biases. Further, these observational tasks were conducted in families' homes, rather than in the laboratory, which increased their ecological validity. Third, the collection of salivary cortisol allowed for the measurement of emotion responding at multiple levels of analysis to better understand the coaction between behavior and physiology. Finally, use of a prospective longitudinal design with consistent measurement across time points allowed me to examine developmental change in emotion functioning, as well as bidirectional associations with parenting behavior.

Despite its strengths, the current study had at least three limitations. As mentioned previously, the use of LPA was beneficial in providing greater specificity with respect to heterogeneity across aspects of emotion responding, but also required some simplification of measurement of the individual indicators. Rather than using the best practice for measuring cortisol reactivity, I used a difference subtracting baseline levels from 20-minutes post-challenge levels in order to improve the interpretability of the LPA results. Similarly, I used a mean score of various ER behaviors to make interpretation easier, whereas an examination of specific ER behaviors may be beneficial for understanding ER in isolation during infancy. Additionally, the computational complexity of the conditional LTA model restricted the ability to test some hypotheses. Because of the sheer number of possible pairwise comparisons across all three time points, I was only able to test the effects of parenting behavior for the emotion profiles versus the ‘non-reactors’ and ‘synchronous reactors’ groups. However, these two groups were present at every age, and the other groups generally fell between them with respect to their levels of reactivity and regulation. Similarly, computational complexity prevented me from testing any mediation effects of emotion responding or parenting behavior at 15 months. Finally, although I was able to examine the effects of parenting behavior on emotion profile membership at 15 and 24 months, I was not able to test parenting effects on transition probabilities over time. However, the estimation of various structural equation modeling techniques, including LPA and LTA, are being innovated rapidly. Hopefully, estimation and computation of these models will be made easier in the near future, enabling the more interesting and complex questions about emotional development to be answered.

Conclusion

The ability to regulate emotions is an important skill that infants and children learn throughout development, and it is critical to consider how ER develops in the context of emotion arousal. The current study demonstrates that a person-centered approach is well-suited for investigating the synchrony of emotion reactivity and regulation across multiple levels of analysis during infancy. Of course, such data-driven methods should be used caution and reliance on strong theory for evaluating results (Nylund, Asparouhov, & Muthén, 2007). The profiles of emotion responding found herein are well-aligned with theoretical expectations and will likely be useful for predicting and understanding emotion development beyond infancy. However, it remains to be seen which profile(s) are more or less adaptive, and in which circumstances and contexts they are adaptive. Additionally, the bidirectional influences involving the ‘synchronous regulators’ and harsh-intrusive parenting present a potentially meaningful developmental cascade. Given that these results are sample-specific, though, further research is needed to replicate the emotion profiles and bidirectional effects found. Still, LPA and LTA will likely be useful tools in investigating other intertwined aspects of early emotion functioning, including joint function of behavior, multiple physiological systems, and neural responding.

CHAPTER III

STUDY 2. TRAJECTORIES OF CHILDREN'S CONDUCT PROBLEMS, ATTENTION-DEFICIT/HYPERACTIVITY DISORDER SYMPTOMS, AND LIMITED PROSOCIAL BEHAVIOR DURING MIDDLE CHILDHOOD AND THEIR LINKS WITH PSYCHOPATHOLOGY AT 12 YEARS OLD

Introduction

Conduct problems (CPs)—which subsume both oppositional defiant and conduct disordered behaviors delineated in the DSM-5 (American Psychological Association, 2013)—refer to angry, defiant, antisocial, aggressive, and norm-violating behaviors among children and adolescents (Kimonis, Frick, & McMahon, 2014; Lorber, 2004). These problem behaviors appearing in childhood and adolescence present public health and safety concerns, as those who engage in life-course persistent antisocial behavior (5-10% of the population) account for over half of all crime in the United States (Eme, 2015; Vaughn, Salas-Wright, DeLisi, & Maynard, 2014). Early-appearing CPs not only confer societal costs, but also personal risks to the children who evidence them, including deficits in social competence (Chen, Drabick, & Burgers, 2015), lower school readiness and achievement (Lewis, Asbury, & Plomin, 2017), and worse mental and physical health (Bevilacqua, Hale, Barker, & Viner, 2017). However, there is significant clinical heterogeneity in the onset, presentation, and course of CPs across childhood and adolescence, indicating need for examining subtypes and comorbidity of CPs in order to identify those at greatest risk for lasting antisocial behavior and related negative outcomes (Frick & Viding, 2009; Sebastian et al., 2014).

Over the last two decades, substantial research has focused on the childhood and adolescent trajectories of CPs, particularly on the early-onset-persistent, adolescent-onset, and childhood-limited patterns theorized by Moffitt (2006). These trajectories have generated numerous findings delineating differential predictors and outcomes, with children following the early-onset-persistent path typically experiencing the most negative early-childhood risk factors and having the most problematic adolescent and adult outcomes. However, inclusion of other explanatory factors is needed to better understand the antecedents, presentation, and consequences of CPs. Attention-deficit/hyperactivity disorder (ADHD) and callous-unemotional (CU) behaviors have been posited as means of differentiating subtypes of childhood CPs, with both having been independently associated with more severe and persistent CPs over time (Danforth, Connor, & Doerfler, 2016; Odgers et al., 2008; Frick & White, 2008, Rowe et al., 2010). Although CP, ADHD, and CU behavior trajectories have been examined independently, only a handful of previous studies have assessed joint trajectories or associations between individual trajectories (e.g., Klingzell et al., 2016; Shaw, Lacourse, & Nagin, 2005), none of which (to my knowledge) included CPs, ADHD symptoms, and CU behaviors in the same study. The current study used longitudinal latent class analysis (LLCA) to examine joint trajectories of CPs, ADHD, and CU behaviors from 3 years old to 5th grade. To assess the validity and clinical utility of the resulting patterns of behavior, I will test their prediction of children's diagnosed ADHD, oppositional defiant disorder (ODD), and conduct disorder (CD), and high CU behaviors at 12 years old.

Conduct Problem Trajectories Across Childhood

As noted previously, Moffitt and her colleagues proposed that children and adolescents with CPs can be differentiated by their onset and persistence of problem behavior, and that these trajectories reflect differences in origin and outcome (Moffitt, 2006; Odgers et al., 2008). In their view, individuals who follow an early-onset-persistent trajectory develop CPs through a confluence of various individual and environmental risk factors, such as neurocognitive deficits, hyperactivity, self-regulation deficits, negative parenting, and low socioeconomic status. Further, these individuals are expected to show the most severe CPs over time and the most negative outcomes across functional domains (Sentse, Kretschmer, de Haan, & Prinzie, 2017). The adolescent-onset trajectory, however, is thought to reflect difficulties with increased autonomy, challenging authority, and risk taking that emerge from affiliating with deviant peers and/or seeking social status, rather than from early risk factors. They may show slightly or moderately less severe CPs and negative outcomes in adolescence and adulthood than those with early-onset-persistent problems (Kretschmer et al., 2014; Miller, Malone, Dodge, & Conduct Problems Prevention Group, 2010; Roisman, Aguilar, & Egeland, 2004). Finally, the childhood-limited group may face early risk factors similar to those of the early-onset-persistent group, but some intervening experiences may cause their CPs to desist. It has been suggested that either resilience factors (e.g., integration in to school and peer groups, positive parenting or role-modeling) help them desist completely from psychopathology, or their CPs lead to peer rejection and subsequent internalizing problems that take the place of CPs (Barker, Oliver, & Maughan, 2010; Moffitt et al., 2008; Veenstra, Lindenberg, Verhulst, & Ormel, 2009). The childhood-limited trajectory has been associated with fewer negative long-term outcomes than the other two problem trajectories, but still more than those of individuals who evidence no childhood CPs (Bevilacqua et al., 2017).

Indeed, there has been general empirical support across low- and high-risk samples for the presence of these trajectories, with some variation depending on the ages during which children's CPs are measured. For example, a recent study by Sentse and colleagues (2017) had mothers report on their children's CPs from when they were 4-7 years old until they were 14-17 years old and found the same trajectories outlined by Moffitt and colleagues. Likewise, Miller et al. (2010) found increasing, desisting, chronic, and non-problem groups when following children from 7-12 years; whereas Shaw, Hyde, and Brennan (2012) reported stable low, high decreasing, late increasing, and high increasing groups among boys from 10-17 years old. A recent study of younger children's ODD symptoms from 3-6 years old also found high persistent, decreasing, increasing and no-ODD groups, with the addition of a low-persistent group (Ezpeleta, Granero, de la Osa, Trepat, & Domènech, 2016). However, there have been some contradictory findings, with another study of ODD irritable, defiant, and antagonistic symptom trajectories finding stable low, medium, and high groups using an accelerated longitudinal design that followed girls from 5-13 years old (Boylan et al., 2017).

ADHD and Conduct Problems Across Childhood

Together, ADHD and CPs represent two of the leading causes of referral for mental health services in childhood (Burke, Mulvey, & Schubert, 2015). Children and adolescents often have comorbid ADHD and CPs (APA, 2013), with estimates of comorbidity rates between 30-60% for ADHD and ODD (Barkley, 2006; Biederman, 2005). Indeed, Beauchaine and colleagues (Beauchaine, Hinshaw, & Pang, 2010; Beauchaine & Gatzke-Kopp, 2012; Beauchaine & McNulty, 2013) have suggested that most adult males with antisocial personality disorder have a history of childhood ADHD that is followed by the emergence of ODD and CD. They have proposed a biopsychosocial model linking ADHD and CPs, in which genetic predisposition and prenatal experiences give rise to early impulsive neurocognitive and behavioral functioning, which gives rise to ADHD in early childhood. Utilizing Patterson's model of coercive parent–child interactions (Patterson, 1982; Patterson, DeGarmo, & Knutson, 2000), they suggest that children's hyperactive and inattentive behaviors elicit negative and inconsistent caregiving from parents that negatively reinforce oppositional, defiant, and aggressive behavior from children; and those behaviors, in turn, negatively reinforce maladaptive parenting. For example, when a child with ADHD does not complete a task they have been asked to do by their parent (e.g., cleaning up toys) because of their hyperactivity or inattention, it may elicit a harsh command by the parent to complete the task. With such harshness being aversive to the child, he/she may become upset and act defiantly or aggressively, which leads to stronger commands from the parent, and even more upset from the child. If the parent, then, gives in to the child's protests, their dysregulated, defiant, and/or aggressive behavior is negatively reinforced for future interactions (as is the parent's acquiescence because it results in an end to the child's aversive behavior). Over time, repeated coercive interactions such as these serve to canalize children's behavioral responses to stress and aversive stimuli into patterns characterized by continued ADHD and emerging CPs.

Of course, not all children with ADHD follow such a developmental course of increasingly problematic behavior, as it necessarily involves complex transactions at biological, psychological, and social levels of analysis (Gottlieb, 2007). For example, parents who are able to respond sensitively to their children's ADHD symptoms over time may be able to prevent them from progressing toward CPs (Beauchaine & McNulty, 2013). These possibilities are reflected in the trajectories that have been evidenced in person-centered empirical studies of ADHD. Few studies have examined trajectories of ADHD longitudinally, but those that have done so have generally found groups of children showing stable low, stable high, increasing, and decreasing ADHD symptoms across childhood (see O'Neill Rajendran, Mahbubani, & Halperin, 2017 for a review). For example, Pingault et al. (2011) reported individual trajectories of children's teacher-reported hyperactivity and inattention characterized by those four profiles among children followed from 6-12 years old. Notably, Sasser and colleagues followed children from pre-K to 5th grade and found that children's teacher-reported inattention symptoms fit the same four profiles (Sasser, Beekman, & Bierman, 2015). However, in a separate sample, they found that children's parent-reported hyperactivity and inattention symptoms across grades 3, 6, 9, and 12 were reflected in three profiles: stable low, declining, and stable high (Sasser, Kalvin, & Bierman, 2016). Likewise, others have found discrepant 3- and 4-class models of ADHD (Robbers et al., 2011; Romano, Tremblay, Farhat, & Côté, 2006), suggesting the need for further longitudinal studies, including those that assess potentially comorbid CPs, and that utilize multiple reporters (O'Niell et al., 2017).

To my knowledge, no existing studies have examined joint trajectories of ADHD and CP across childhood or adolescence, but a handful have modeled individual ADHD and CP trajectories in the same sample. Whereas some have not assessed associations between the ADHD and CP trajectories because their focus was on other predictor or outcome variables (e.g., Galera et al., 2018; Musser, Karalunas, Dieckmann, Peris, & Nigg, 2016; Nagin & Tremblay, 1999), two studies have assessed children's joint membership in the distinct ADHD and CP groups. Using an accelerated longitudinal design following children from 4-18 years old, van Lier and colleagues found that children who exhibited a stable high ADHD trajectory were most likely to also exhibit a stable moderate CD trajectory. However, one third of those children in the stable high ADHD group were classified in the "adolescent peak" CD group, which was characterized by moderate CD in childhood that increased to much higher levels of CD in adolescence, compared to other children (van Lier, van der Ende, Koot, & Verhulst, 2007). Similarly, Shaw and colleagues (2005) assessed children's ADHD and CP symptoms longitudinally from 2-10 years old and reported that 19.2% of children who were classified in the chronic high ADHD symptom group were also classified in the chronic high CP group. An additional 73.1% of children in the chronic ADHD group were classified in the moderate declining (but not desisting) CP group, meaning that over

90% of children with persistently high ADHD symptoms showed moderate or high CPs over time. Further, of children classified in the chronic high CP group, 55.6% were also classified in the chronic high ADHD group and 38.9% were classified in the moderate stable ADHD group (again, over 90% combined). Taken together, these findings suggest that many children with continually high ADHD across childhood are at risk for showing similarly severe CPs over the same time. However, more children with stable high ADHD show moderate, rather than stable high, CPs, indicating that the presence of ADHD does not fully explain the heterogeneity in childhood CP trajectories.

Callous-Unemotional Behaviors and Conduct Problems Across Childhood

Callous-unemotional (CU) behaviors refer to the affective component of psychopathy characterized by callousness, a lack of empathy, a lack of guilt, and shallow and/or deficient emotions (Frick, Ray, Thornton, & Kahn, 2014). This affective phenotype can be measured in early (Hyde et al., 2013; Kimonis et al., 2016; Willoughby, Mills-Koonce, Gottfredson, & Wagner, 2014; Willoughby, Waschbusch, Moore, & Propper, 2011) and middle childhood (Frick & Viding, 2009; Hawes et al., 2014; Willoughby, Mills-Koonce, Waschbusch, & Gottfredson, & the Family Life Project Investigators, 2015) and has been proposed as modifier that can account for some of the heterogeneity in CPs, particularly because children with elevated CU behaviors may show the most severe, violent, and persistent CPs over time (Frick & White, 2008; Rowe et al., 2010). As a result, the DSM-5 includes a CU behavior specifier (labeled as "limited prosocial emotions") for diagnoses of conduct disorder (APA, 2013).

The proposed developmental connections between CU behaviors and CPs have largely centered on aspects of CU behaviors that prevent children from feeling, noticing, or attending to the negative consequences of engaging in CPs. Frick and colleagues have posited that children with CU behaviors exhibit temperamental fearlessness, punishment insensitivity, over-focus on reward, and decreased responding or awareness of distress in others (Frick et al., 2014; Frick & Viding, 2009; Frick & White, 2008). In typically developing children, fear, punishment, and distress by others present aversive stimuli that serve to discourage CPs. For example, when a child acts aggressively toward a peer, and that peer then cries as a result (or the aggressive child is punished by an adult), the peers' distress (or resulting punishment) is thought to cause discomfort in the aggressive child and discourage future aggressive behavior (Dadds & Salmon, 2003; Kochanska, 1993). Among children with CU, though, insensitivity to punishment, over-focus on reward, and decreased awareness of (or attention to) distress cues may inhibit their ability to feel the discomfort necessary for reducing further aggression. Over repeated experiences, these responses (or lack thereof) to supposedly aversive stimuli canalize into a behavioral phenotype characterized by low guilt and empathy, which promote continued CPs in the context of limited negative feedback for misbehavior.

Similar to the previous research on CPs and ADHD, a small existing literature has focused on heterogeneity of CU behavior trajectories throughout childhood and adolescence using person-centered approaches. Fanti et al. and Fontaine et al. both found 4-class models characterized by stable low, stable high, increasing, and decreasing patterns during late childhood and early adolescence (9-12 and 7-12 years old, respectively; Fanti, Colins, Andershed, & Sikki, 2017; Fontaine, Rijsdijk, McCrory, & Viding, 2011). Interestingly, Byrd and colleagues (2018) recently reported results similar to those of typical CPs among children followed from 8-15 years old, with a 5-class model reflecting early-onset-persistent, adolescent-onset, childhood-limited, moderate stable, and stable low CU. On the other hand, Goulter et al. (2017) found stable low, moderately low, moderately high, and high trajectories from 7-15 years old; and Baskin-Sommers and colleagues found stable low, moderate, and high trajectories across adolescence and into young adulthood using an accelerated longitudinal design (15-19 to 20-24 years old; Baskin-Sommers, Waller, Fish, & Hyde, 2015). Taken together, the limited literature follows a similar pattern of mixed findings to those of CP and ADHD trajectories.

However, a handful of studies have examined joint trajectories of CPs and CU behaviors, unlike previous research on ADHD and CPs. Fontaine and colleagues, following children from 7-12 years old, first assessed CU behaviors alone and found that the best-fitting model reflected stable low, stable high, increasing, and decreasing trajectories. They then combined these trajectories with a manually selected two-class model of CPs (high and low), resulting in seven CP-CU classes (no children demonstrated high CP with low CU behaviors over time). Interestingly, they found that stable high or increasing CU behaviors paired with high CPs were associated with greater hyperactivity at age 12 (Fontaine, McCory, Boivin, Moffitt, & Viding, 2011).

Klingzell and colleagues (2016), on the other hand, examined empirically derived CPs and CU behaviors using an accelerated longitudinal design from 3-5 to 5-7 years old.

They reported a 5-class model of combined trajectories with (1) stable low CPs and CU, (2) stable high CPs and low CU, (3) decreasing CPs and CU, (4) increasing CPs and CU, and (5) stable high CP and CU behaviors. Finally, Ezpeleta et al. (2017) examined joint trajectories of ODD symptoms, CU behaviors, and anxiety symptoms from 3-7 years old. They found a 6-class model with (1) stable low ODD, CU, and anxiety; (2) stable high ODD, CU, and anxiety; (3) stable low ODD, stable low CP, and increasing anxiety; (4) stable low ODD, stable low CP, and decreasing anxiety; (5) increasing ODD, stable high CU, and stable low anxiety; and (6) decreasing ODD, stable high CU, and stable low anxiety. Although anxiety is not a focus of the current study, their findings (along with those of Klingzell et al.) indicate that the inclusion of CU behaviors in models of CP trajectories provides qualitatively distinct patterns of behavior across childhood. Given the findings from previous studies of ADHD, assessing joint trajectories of CPs, ADHD, and CU has promise for delineating heterogeneity in CPs that has relevance for both etiology and outcomes.

Current Study

The current study attempted to extend the previous research on the developmental course of CPs, ADHD, and CU behaviors by examining joint trajectories of children's CPs, hyperactivity, and limited prosocial behavior (as a proxy for CU behaviors) longitudinally from 3 years old to 5th grade using longitudinal latent class analysis (LLCA). Because diagnosis of ADHD requires the presence of symptoms in multiple settings, and both ODD and CD diagnoses require distress and/or impairment that can occur in multiple potential settings (APA, 2013), I utilized both parent-reports (yearly from 3 years old to 1st grade) and teacher-reports (yearly from childcare [i.e., 3 years old] to 5th grade) of children's psychopathology symptoms. Using both parent- and teacher-reports offers the opportunity to examine meaningful differences in individual children's behavior across settings (Burns & Haynes, 2006; Dishion, Burraston, & Li, 2002). Additionally, I assessed the predictive validity and clinical utility of the resulting joint trajectories by examining associations between trajectory membership and diagnoses of children's ADHD, ODD, and CD, as well as high CU behaviors at 12 years old (see Figure 5 for full conceptual model). I hypothesized that children's behavior would follow five different trajectories: (1) stable low CPs, hyperactivity, and limited prosocial behavior; (2) stable high CPs, hyperactivity, and limited prosocial behavior; (3) stable high CPs and hyperactivity, but low limited prosocial behavior; (4) decreasing CPs and hyperactivity, and stable low limited prosocial behaviors; and (5) increasing CPs and hyperactivity, and stable low limited prosocial behavior. Finally, I hypothesized that the stable high CPs, hyperactivity, and limited prosocial behavior group would show the greatest likelihood of ADHD, ODD, and CD diagnoses, and the presence of high CU behaviors at 12 years old, followed by the stable high CPs and hyperactivity group with low limited prosocial behavior and the increasing CPs and hyperactivity group low limited prosocial behavior, which were not expected to differ from one another in likelihood of diagnoses. The decreasing CPs and hyperactivity group, and the stable low CPs, hyperactivity, and limited prosocial behavior group were expected to have lower likelihood of diagnoses and CU behaviors than the other groups, with the stable low group showing the lowest probability of all groups.

Methods

Participants

The Family Life Project is a large longitudinal study of children and families living in nonurban, lower income communities in the United States. Families and their newborns that lived in two major geographical areas of high child rural poverty (including three counties in eastern North Carolina and three counties in central Pennsylvania) were recruited using a stratified random sampling procedure yielding a representative sample of 1,292 families recruited over a one-year period at the time mothers gave birth to a child. The sample was recruited to be representative of every baby born to an English-speaking mother living in the counties selected during the year of recruitment, while also oversampling for poverty and race (i.e., African American). The full sample included 549 African American (42.5%) children, 736 European American (57%) children, 7 children of other race (0.5%), 657 girls (50.9%), and 635 boys (49.1%). See Willoughby and colleagues (2013) and Garrett-Peters and Mills-Koonce (2013) for more information on the recruitment of the Family Life Project sample. Full-information maximum likelihood (FIML) estimation was used to account for missing data.

Procedures

Children and families were visited for in-home data collection when children were 2, 6, 15, 24, 36, 48, and 60 months old, and in 1st grade. In addition to various observational tasks that were completed at each visit, primary caregivers (99.6% biological mothers at 2 months) completed a variety of questionnaires, including those pertaining to children's behavior. When children were approximately 36 months old, teachers completed questionnaires about children's behavior on a yearly basis, until children were in 5^{th} grade. Both parents and teachers completed the Strengths and Difficulties Questionnaire (SDQ), a brief screening questionnaire that includes subscales pertaining to children's CPs, hyperactivity, and prosocial behavior (Goodman, 1997). The SDQ uses 3-point Likert-type items to assess how true various statements are of the child (i.e., "not true", "somewhat true", "certainly true"). Parents completed the SDQ at the 36-month, 48-month, 60-month, and 1^{st} grade home visits, whereas teachers completed it at the childcare, pre-K, Kindergarten, and 1^{st}-5^{th} grade school visits. Given that the home visits occurred within a year of the childcare (36 months), pre-K (48 months), Kindergarten (60 months), and 1^{st} grade (1^{st} grade home) school visits, these visits were matched and considered as the same time point for the current study.

When children were 12 years old, they were visited again for in-home data collection. As part of that home visit, the Diagnostic Interview Schedule for Children (DISC; Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000) was administered to parents by researchers in order to assess psychological disorders for which their children met diagnostic criteria. The DISC is a structured diagnostic interview based on DSM-5 diagnostic criteria.

Measures

Conduct problems. Children's conduct problems were measured at each home- and school-visit using the conduct problems subscale of the SDQ. The subscale includes five items: (1) "often loses temper"; (2) "generally well behaved, usually does what adults request (reverse scored)"; (3) "often fights with other children or bullies them"; (4) "often lies or cheats"; and (5) "can be spiteful to others". In order to index clinically relevant levels of CPs, the normed data for children in the United States (see http://www.sdqinfo.com/norms/USNorm.html) were used to create a dichotomous variable denoting CP scores below the United States normed 90th percentile and those at or above that cutoff.

Hyperactivity. Children's hyperactivity was measured at each home- and school-visit using the hyperactivity subscale of the SDQ. The subscale includes five items: (1) "Restless, overactive, cannot stay still for long"; (2) "Constantly fidgeting or squirming"; (3) "Easily distracted, concentration wanders"; (4) "Thinks things out before acting", and (5) "Good attention span, sees work through to the end". As with CPs, the US normed data were used to create a dichotomous variable denoting scores below the 90th percentile and those at or above that cutoff.

Limited prosocial behavior. Children's limited prosocial behavior was measured at each home- and school-visit using the prosocial behavior subscale of the SDQ. The subscale includes five items: (1) "Considerate of other people's feelings"; (2) "Shares readily with other children, for example toys, treats, pencils"; (3) "Helpful if someone is hurt, upset or feeling ill"; (4) "Kind to younger children"; and (5) "Often offers to help others (parents, teachers, other children)". In order to index *limited* prosocial behavior, the US normed data were used to create a dichotomous variable denoting scores at or below the 10th percentile and those above that cutoff. Children scoring at or below the 10th percentile were labeled as showing limited prosocial behavior.

ODD, CD, and ADHD diagnoses. At 12 years old, children's diagnoses of ODD, CD, and ADHD were measured using the DISC. Dichotomous variables were created for each disorder, reflecting having met or not met criteria for diagnosis based on the results of the DISC.

Callous-unemotional behaviors. Callous-unemotional behaviors were assessed with the Inventory of Callous-Unemotional Traits (ICU; Essau, Sasagawa, & Frick, 2006), a series of 24 items on a 4-point Likert scale developed from other highly established clinical assessments (e.g., Antisocial Personality Screening Device, Psychopathy Checklist-Youth Version). Examples of items include "does not care who s/he hurts to get what s/he wants" and "seems cold and uncaring to others", "expresses his/her feelings openly" (reverse-scored) and "does things to make others feel good" (reverse-scored). A recent meta-analysis found that the reliable variance in the ICU subfactor scores were strongly influenced by the general factor, suggesting that, across samples, the ICU total score best represents the CU behavior construct (Ray & Frick, 2018). In order to identify children showing clinically significant levels of CU behaviors similar to the diagnostic criteria for the other 12-year outcomes, I used a cutoff at the 90th percentile of children's ICU total scores. Although there are no set guidelines that designate clinical levels of CU behaviors, I was confident that the 90th percentile cutoffs used designate children that were showing very high levels of CU behaviors in the clinical range.

Covariates. Child gender, child race, and primary caregivers' years of education were reported by primary caregivers when they were recruited at the time of their child's birth (and confirmed at each home visit). Family income-to-needs ratio (total household income divided by the 2005 federal poverty threshold) was reported by primary caregivers when children were 36, 48, and 60 months old, and in 1st grade; the mean income-to-needs ratio across these visits was used for the analyses.

Analysis Plan

Longitudinal latent class analysis was used to identify groups of children with similar trajectories of CPs, hyperactivity, and limited prosocial behavior from childcare to 5th grade. All models were fit using Mplus 8.2 (Muthén & Muthén, 1998–2017). Missing data were handled using full information maximum likelihood methods (Enders & Bandalos, 2001). Given the stratified random sampling design, the robust maximum likelihood estimator (MLR) was used to estimate all models to allow for inclusion of individual probability weights associated with oversampling of low-income and African American families and stratification on income, state, and race. The optimal number of classes was determined based on a balance of theory, interpretability, and model fit using the Bayesian information criteria (BIC), sample size-adjusted Bayesian information criteria (ssBIC), and adjusted Vuong-Lo-Mendell-Rubin likelihood ratio test (aVLMR; Henson, Reise, & Kim, 2007; Nylund, Asparouhov, & Muthén, 2007).

After determining the optimal number of classes, multivariate logistic structural regression was used to assess prediction of children's ODD, CD, and ADHD diagnoses by their membership in the trajectories, above and beyond the influence of covariates. As a whole, these analyses followed a three-step approach for examining outcomes of LCAs (Asparouhov & Muthén, 2013; Nylund-Gibson & Maysn, 2016). In this approach, the class enumeration process is done using an unconditional model, in which no covariates are included, allowing for the observation of various trajectories "in-vivo" without covariates unintentionally impacting the optimal number of classes or children's class membership probabilities. After the optimal number of classes is determined, the conditional path analysis predicting 12-year diagnoses can be conducted with covariates included.

Results

Descriptive Statistics

Table 8 presents bivariate correlations among central variables and covariates. Given the large number of indicators from parents' and teachers' reports on the SDQ, the CP, hyperactivity, and limited prosocial behavior variables in Table 8 represent means of those behaviors from 3 years old to 5^{th} grade in order to provide a general sense of their correlations with one another and with the other study variables. Notably, all three behaviors rated on the SDQ were significantly positively correlated with one another, as well as with all the 12-year outcomes. These correlations were in the small-to-moderate range, with the largest correlation among SDQ variables between CPs and limited prosocial behavior ($r = .54$), the largest among 12-year outcomes between ADHD and ODD ($r = .41$), and the largest longitudinal correlation between hyperactivity and ADHD ($r = .51$).

Latent Class Analysis

Class enumeration. First, an unconditional LCA was conducted to determine the optimal number of classes. Initial model runs revealed that there was too much missing data at 4th grade for that time point to be included (>90% missing). Therefore, all models were conducted without 4th grade SDQ data. Models that included between 2-7 classes were tested. Table 9 presents the fit statistics for each model. Based on theory, interpretability, and fit statistics, the 4-class model was determined to be the best-fitting. Although the fit indices provided contradictory information suggesting similar fit of the 4-, 5-, and 6-class models, the 4-class model provided the most theoretically meaningful, interpretable, and parsimonious results. Notably, the 4-class model resulted in four substantively distinct behavior trajectories, whereas the 5- and 6-class models included groups that were very similar or overlapping.

Class Descriptions

Figure 6 illustrates the joint trajectories of CPs, hyperactivity, and limited prosocial behavior for each of the four classes. The most prevalent group (44.3% of the sample) was rated by both parents and teachers as having a stable low probability of showing CPs, hyperactivity, and limited prosocial behavior over time (i.e., stable low group). The second most prevalent group (21.8%) was rated by parents as having a high probability of CPs and hyperactivity with a slight decreasing trend, but low limited prosocial behavior, whereas teachers rated those children as having a stable low probability of CPs, hyperactivity, and limited prosocial behavior (i.e., parent high decreasing group). Conversely, another group (20.3%) was rated by parents as showing a stable low probability of CPs, hyperactivity, and limited prosocial behavior, but rated by teachers as having a low probability of CP, hyperactivity, and limited prosocial behavior that increased to moderately high levels over time (teacher increasing group). The final group (13.6%) was rated by both parents and teachers as having a stable high probability of CPs and hyperactivity, but parents generally rated children as stable low on limited prosocial behavior and teachers rated them as stable high on that behavior (i.e., stable high group).

Taken together, the resulting trajectories were partially consistent with hypotheses. Table 10 shows a comparison of the hypothesized trajectories with those from the estimated model, with the ‘stable low’ group being largely consistent with the first hypothesized trajectory and the other three groups showing elements of the other hypothesized trajectories. Most notably, though, the resulting trajectories reflected reporter agreement and disagreement among parents and teachers about children’s behavior over time. Two of the groups demonstrated the expected stable low and stable high trajectories across reporters, whereas the other two groups showed differences in children’s behavior across contexts, with parents rating children as high on problem behavior and teachers rating those same children as low in one group, and vice versa in the other group. For teacher ratings, children’s CPs, hyperactivity, and limited prosocial behavior were rated similarly within groups (e.g., if CPs were rated highly, so were hyperactivity and limited prosocial behavior. For parent ratings, however, children’s CPs and hyperactivity were rated similarly within groups, but parents generally showed a low probability of rating their children as having limited prosocial behavior across all groups.

Despite the partial consistency with the expected trajectories, the resulting groups showed substantive behavior differences that still enabled assessment of their predictive validity with respect to psychopathological outcomes at 12 years old.

Prediction of 12-Year from Latent Class Trajectories

After determining the optimal number of trajectories based on the SDQ parent- and teacher-reports, I assessed their predictive validity by conducting a multivariate logistic structural regression testing associations with diagnoses of ODD, CD, and ADHD diagnoses, as well as high CU behaviors (90^{th} percentile or above) at 12 years old. A significant omnibus Wald test suggested that the trajectories were predictive of the psychopathological outcomes at 12 years old, χ^2 (12) = 90.05, p < .0001.

ADHD diagnosis. Table 11 presents the parameter estimates comparing the likelihood of ADHD, ODD, and CD diagnosis, and of showing high CU behaviors, based on children's membership in the trajectories of CPs, ADHD, and limited prosocial behavior. Results indicated that children in the 'stable high', 'parent high decreasing', and 'teacher increasing' trajectories were 34.65, 5.83, and 7.02 times more likely, respectively, to be diagnosed with ADHD at 12 years old than the 'stable low' trajectory. Children in the 'stable high' group were also 4.94 and 5.94 times more likely to be diagnosed with ADHD than the 'teacher increasing' and 'parent high decreasing' groups, respectively. However, the 'parent high decreasing' and 'teacher increasing' groups did not differ from one another in risk for ADHD diagnosis.

ODD diagnosis. Similar to ADHD diagnosis, children in the 'stable high', 'parent high decreasing', and 'teacher increasing' groups were 16.48, 4.32, and 2.98

times more likely, respectively, to be diagnosed with ODD at 12 years old than children in the ‘stable low’ group. In addition, children in the ‘stable high’ group were 5.54 and 3.82 times more likely to be diagnosed with ADHD than children in the ‘teacher increasing’ and ‘parent high decreasing’ groups, respectively. Again, the ‘parent high decreasing’ and ‘teacher increasing’ groups did not differ from one another in risk for ODD diagnosis.

CD diagnosis. Children in the ‘stable high’ group were 16.13 times more likely to be diagnosed with CD at 12 years old than children in the ‘low stable’ group. They were also 22.53 times more likely than the ‘teacher increasing’ group to be diagnosed with CD, but were not more likely to be diagnosed than the ‘parent high decreasing’ group. In addition, the ‘parent high decreasing’ and ‘teacher increasing’ groups did not show significantly greater risk for diagnosis than the ‘stable low’ group.

CU behaviors. Finally, children in the ‘stable high’ group were 14.51 times more likely to show high levels of CU behaviors ($\geq 90^{th}$ percentile) at 12 years old than children in the ‘stable low’ group, and 15.53 time more likely than those in the ‘teacher increasing’ group. As with CD diagnosis, though, they were not more likely than the ‘parent high decreasing’ group to show CU behaviors; and the ‘parent high decreasing’ and ‘teacher increasing’ groups did not differ significantly from one another in their risk for CU behaviors.

Discussion

The first goal of the current study was to use a person-centered approach, LLCA, to delineate heterogeneity in CPs through joint trajectories with ADHD symptoms and limited prosocial behavior based on ratings by both parents and teachers. The results of the LLCA were partially consistent with study hypotheses. I found two expected groups that showed stable low and stable high trajectories of CPs, ADHD, and limited prosocial behavior across reporters (with the exception of parents rating children as low on limited prosocial behavior in the 'stable high' group). Contrary to expectations, I did not find any groups that reflected heterogeneity in CPs based on the presence or absence of ADHD or limited prosocial behavior. Rather, the resulting groups were generally characterized by behaviors that were jointly high, low, or increasing (e.g., high CPs were accompanied by high hyperactivity and limited prosocial behavior). Although I did not find heterogeneity across these types of behavior, two groups showed heterogeneity in parents' and teachers' perceptions of children's behavior, with parents rating children as high and slightly decreasing on CPs and hyperactivity in one group and teachers rating children as increasing over time on all three behaviors in the other. These results suggest that parents' and teachers' perceptions of children's behavior and/or actual differences in children's behavior across contexts are important for explaining heterogeneity in problem behavior across childhood and risk for clinically significant psychopathology in preadolescence. However, they also raise important questions about the utility of LLCA for assessing joint trajectories of CPs, ADHD, and CU behaviors. Specifically, LLCA may or may not be sensitive enough to detect heterogeneity in individual behaviors when analyzing joint trajectories, but the sensitivity of the SDQ for detecting behavior may also contribute to this issue.

Utility of Latent Class Analysis for Assessing Heterogeneity in Conduct Problems

The current study used LLCA to model trajectories because it addresses some of the limitations of other methods. Most notably, this person-centered approach allows for the observation of heterogeneity that cannot be observed using variable-centered methods. In addition, other person-centered approaches, such as growth mixture modeling, allow for observations of heterogeneity in trajectories over time, but do not allow for the observation of joint trajectories of multiple types of behavior (Ram & Grimm, 2009). By allowing for the modeling of joint trajectories of multiple constructs, LLCA has the potential to fill a gap in the existing research on heterogeneity in CPs across childhood. In the current study, however, heterogeneity was driven primarily by the differences among parents' and teachers' reports. Given the moderately high correlations among CPs, hyperactivity, and limited prosocial behavior in sample, it is likely that most children showing high levels of one behavior also showed high levels on the others. Although there are certainly children who show a mismatch of these problem behaviors, as demonstrated in previous research in this sample (e.g., high CPs, but low CU; see Rehder et al., 2017 for an example), there are likely not enough children showing such divergence in their behavior to drive the results of an LLCA. Alternatively, it is possible that the SDQ subscales used were not sensitive enough to adequately detect children with diverging levels of CPs, ADHD, and CU behaviors, given that each subscale included only five items. More detailed measures may have allowed for better detection of children with each type of problem behavior, leading to increased likelihood of having enough children with diverging patterns of problem behavior to be reflected in the LLCA.

In LLCA, within-class variance in the indicators is constrained (Feldman, Maysn, & Conger, 2009), meaning that small numbers of children who differ in their trajectories from most children in the sample are forced into membership in the larger groups. The average class assignment probabilities were high (.85-.91), suggesting that there was low uncertainty in placing children into their respective classes, but some of the uncertainty could be partially due to children with a mismatch among their levels of CPs, hyperactivity, and limited prosocial behavior. With this weakness in mind, a novel approach using person-centered methods that do not constrain within-class variance (e.g., growth mixture modeling) may be appropriate. One approach might be to model CPs, ADHD, and CU behavior trajectories separately using growth mixture models, and then tests of moderation could be conducted when predicting outcomes. Such an approach would be able to assess whether children with stable high CPs and ADHD, but stable low CU behaviors show different outcomes than those who have stable high trajectories for all three behaviors. Alternatively, utilizing clinical samples of children, instead of community samples, may allow for greater detection of differing trajectories of CPs, ADHD, and CU behaviors without the effects being largely driven by children who show few problem behaviors.

Although hyperactivity and limited prosocial behaviors did not delineate heterogeneity in CP trajectories in the current study, LLCA remains a viable option for modeling joint trajectories. Future investigations in other samples are needed further assess the utility of LLCA and examine whether the presence of ADHD and CU behaviors can explain differences in CPs across childhood. Despite these unexpected findings, the resulting trajectories delineated an important heterogeneity factor, reporter and/or setting, particularly with respect to predicting outcomes of these problem behaviors.

Predictive Validity of the CP/Hyperactivity/Limited Prosocial Trajectories

The resulting trajectories only partially supported the hypotheses with respect to group makeup, but the differences among parent- and teacher-reports still enabled the examination of the second goal of the study, predicting diagnostic and behavioral outcomes at 12 years old. Consistent with my hypotheses, the 'stable high' group—which showed the most severe and consistent CPs, hyperactivity, and limited prosocial behavior over time—were several times more likely than the 'stable low' group to meet diagnostic criteria for ADHD, ODD, and CD, as well as to show high CU behaviors. They showed a similar level of risk for all four outcomes compared to the 'teacher increasing' group (that had low parent ratings across dimensions), and had increased risk for ADHD and ODD compared to the 'parent high decreasing' group (that had low teacher ratings across dimensions). Additionally, children in the 'parent high decreasing' and 'teacher increasing' groups both showed significantly greater likelihood of ADHD and ODD diagnoses compared to children in the 'stable low' group, suggesting that they are ordinally at attenuated risk relative to the 'stable high' group, but elevated risk relative to the 'stable low' group. These results suggest strong predictive validity of the CP/hyperactivity/limited prosocial trajectories for all four outcomes at 12 years old. The

CP, hyperactivity, and prosocial subscales of the SDQ are all composed of only five items, but consistently high symptoms across time and reporter conferred extremely high relative probability of meeting diagnostic criteria for ADHD, ODD, and CD, as well as a high threshold for CU behaviors ($\geq 90^{th}$ percentile). Thus, these SDQ subscales may enable researchers to quickly assess risk and enable clinicians to screen for more severe symptomatology. However, including multiple reporters across settings and time appears to substantially improve the predictive validity of this measure.

There are various reason why parent- and teacher-reports of children's behavior may differ, including factors influencing their perceptions of behavior (e.g., biases, attributions, and expectations) and true differences in children's behavior in different contexts (Achenbach, 2011; De Los Reyes, 2011; Tung & Lee, 2018). Although it is not possible with the available data to determine whether parents or teachers were biased reporters in any given group, the presence of 12-year outcomes does allow for some speculation about the source of differences between parents' and teachers' ratings. For example, if teachers in the 'teacher increasing' group were actually rating children's problem behavior as higher than reality, then one would expect the children in that group to show similar risk of ADHD, ODD, and CD diagnoses, and risk of high CU behaviors to the 'stable low' group. However, children in the 'teacher increasing' group showed much higher risk of those negative outcomes than the 'stable low' group, suggesting that the group differences are more likely to be the result of real differences in children's behavior than the result of reporter bias. Further, multiple teachers rated children's behavior as they progressed through school, reducing the likelihood that any one teacher's bias influenced the group differences in trajectories.

Despite the difficulty in determining the cause of discrepant ratings between parents and teachers, the current findings support existing research suggesting that cross-context problem behavior is associated with more negative outcomes than such behavior in a single context, although both have been linked with increased risk relative to children showing few problem behaviors (Munkvold, Lundervold, Lie, & Manger, 2009; Youngstrom, 2011). Thus, the CP/hyperactivity/limited prosocial trajectories provide a theoretically meaningful and practically useful tool for predicting continued problem behavior. However, further research is needed to determine whether these profiles have predictive validity with respect to other outcomes, such as other aspects of mental health, physical health, and social-emotional functioning.

Strengths and Limitations

The current study benefited from at least three important strengths. First, a prospective longitudinal design was used to assess problem behavior trajectories, as opposed to retrospective reports. The presence of several data collection time points from 3 years old through 5th grade further strengthened this design. Second, the study benefited from having both parent- and teacher-reports on children's behavior. As noted previously, children's problem behavior likely varies in important ways across contexts and the inclusion of multiple reporters allowed for the detection of differences that have seemingly major predictive influence on later diagnoses. Third, multiple teachers reported on children's behavior over time, reducing the likelihood of individual teachers' biases, perceptions, or expectations influencing the results. Finally, the use of a rigorous diagnostic interview, the Diagnostic Interview Schedule for Children, and the current gold standard measure of CU behaviors, the Inventory of Callous Unemotional Traits, strengthened the test of predictive validity of the CP/hyperactivity/prosocial trajectories.

The current study also suffered from at least three limitations. First, parents only reported on the SDQ at four of the seven time points included in the final analyses. Having parent reports at all time points would have provided more strength to the conclusions reporter differences on the trajectories, as well as their prediction of 12-year outcomes. Second, the current sample did not have formal measures of CU behaviors throughout childhood, requiring the use of the prosocial scale of the SDQ as a proxy measure. Although the items on the prosocial scale are not specifically designed to measure CU behaviors, they are similar to some items on CU scales, and the 10^{th} percentile cutoff used likely identified children who showed very low amounts of prosocial behavior, akin to the limited prosocial emotions described in the DSM-5. Finally, it should be noted that LLCA is a data driven method, for which the fit indices almost always suggest that more than one class should be extracted, and caution should be used when interpreting the results because they may or may not represent the true nature of the data (Bauer & Curran, 2003). Despite this caution, the trajectories found in the current study are consistent with existing theoretical and empirical work and showed strong prediction of relevant outcomes at 12 years old, providing confidence that the trajectories are likely accurate representations of the data.

Conclusion

Early-onset persistent CPs place children at risk for a variety of negative consequences throughout development. The current study attempted to add to the existing literature on the course of childhood CPs by using a person-centered approach to modeling joint trajectories of CPs, ADHD symptoms, and limited prosocial behavior. Although I did not find that ADHD symptoms and limited prosocial behavior delineated different trajectories of CPs, I did find that parent- and teacher-reports evidenced differences in children's cross-context behavior. Children showing stable high levels of CPs, hyperactivity, and limited prosocial behavior across contexts were at extremely high risk of showing clinical levels of the same problem behaviors in preadolescence compared to children with stable low trajectories. These findings demonstrate the research and clinical utility of assessing behavioral trajectories across childhood. However, further research is needed to assess the role of ADHD, CU behaviors, and cross-context behavior in understanding the onset, persistence, and severity of childhood CPs.

CHAPTER IV

STUDY 3. INFANT EMOTION REACTIVITY AND REGULATION PROFILES, EARLY CHILDHOOD EXECUTIVE FUNCTION, AND TRAJECTORIES OF CONDUCT PROBLEMS, ATTENTION-DEFICIT/HYPERACTIVITY DISORDER SYMPTOMS, AND LIMITED PROSOCIAL BEHAVIOR

Introduction

Over the past two decades, the study of self-regulation has become a major pursuit in developmental science. During infancy and early childhood, emotion regulation (ER) and executive function (EF), in particular, are interrelated aspects of self-regulation that have garnered extensive research and are theorized to promote social competence school readiness and achievement, and adjustment (Calkins, 2007; Morrison, Cameron Ponitz, & McClelland, 2010). Intuitively, the ability of children to express, control, channel, and use their attention, thoughts, and emotions should enable them to engage in positive social interactions, focus on important tasks (e.g., learning in school), and behavior appropriately in various contexts. As such, developing ER and EF (and self-regulation, broadly) abilities has been identified as a central task of early childhood (Calkins, 2007). However, the development of self-regulation is a complex process that occurs through coaction at multiple levels of analysis (i.e., biological, psychological, behavioral, and social; Calkins & Marcovitch, 2010; Gottlieb, 2007), and disruptions and deficits in the development of self-regulation have been implicated in the emergence of psychopathology, including conduct problems (Beauchaine & McNulty, 2013; Nigg & Casey, 2005; Shipman, Schneider, & Brown, 2004).

Conduct problems (CPs)—which subsume both oppositional defiant and conduct disordered behaviors delineated in the DSM-5 (American Psychological Association, 2013)—refer to angry, defiant, antisocial, aggressive, and norm-violating behaviors among children and adolescents (Kimonis, Frick, & McMahon, 2014; Lorber, 2004). These problem behaviors appearing in childhood and adolescence present public health and safety concerns (Eme, 2015; Vaughn, Salas-Wright, DeLisi, & Maynard, 2014), as well as personal risks to the children who evidence them, including deficits in social competence (Chen, Drabick, & Burgers, 2015), lower school readiness and achievement (Lewis, Asbury, & Plomin, 2017), and worse mental and physical health (Bevilacqua, Hale, Barker, & Viner, 2017). However, significant clinical heterogeneity observed in the onset, presentation, and course of CPs across childhood and adolescence has demonstrated a need for examining subtypes and comorbidity of CPs in order to identify those at greatest risk for lasting antisocial behavior and related negative outcomes (Frick & Viding, 2009; Sebastian et al., 2014). Attention-deficit/hyperactivity disorder (ADHD) and callous-unemotional (CU) behaviors have been suggested as potential differentiating factors in children's CPs, as both have been independently associated with more severe and persistent CPs over time (Danforth, Connor, & Doerfler, 2016; Odgers et al., 2008; Frick & White, 2008, Rowe et al., 2010). The current study used person-centered approaches to relate profiles of emotion, ER, and EF during infancy and early childhood to longitudinal profiles of CP, ADHD, and CU in early- and middle-childhood.

Emotion Regulation and Executive Function as Developmentally Integrated Components of Broader Self-Regulation

Although various definition of ER exist, I define ER as the strategies, skills, behaviors, and cognitions that modulate emotional experiences (Calkins & Hill, 2007). It is important to note that ER occurs in response to emotions, which can be defined as the biopsychosocial process of consciously or subconsciously appraising the meaning and importance of internal and external stimuli (Campos, Walle, Dahl, & Main, 2011; Cole, Martin, & Dennis, 2004). Both emotion and ER involve activity at the neural, physiological, cognitive, and behavioral levels (Dennis, Buss, & Hastings, 2012). Executive function, on the other hand, refers to a set of cognitive abilities—including inhibitory control, working memory (a.k.a., updating), and cognitive flexibility (a.k.a., set shifting)—that is important for planning, problem solving, and goal-directed activity (Miyake et al., 2000; Zelazo, 2015). These abilities have garnered significant interest among developmental scientists because of their rapid development during early childhood and their conceptual and empirical links to early functioning across multiple domains (Blair & Razza, 2007; Diamond, 2013). The inhibitory control dimension of EF refers to the ability to control override impulses in favor of less dominant cognitive and/or behavioral responses whereas working memory refers to the ability to hold information in mind and cognitively manipulate it. Cognitive flexibility draws on inhibitory control and working memory and refers to an individuals' ability to recognize and adjust to the changing demands or varying perspectives of situations and/or tasks (e.g., adjusting to rule changes or viewing problems in different ways; Diamond, 2013).

Both ER and EF develop rapidly during infancy early childhood (Garon, Bryson, & Smith, 2008; Sameroff, 2010) and have been theorized to influence one another and become highly integrated over time (Calkins & Marcovitch, 2010). Specifically, ER influences EF by allowing for calm cognition and/or by providing motivation. Children who are able to regulate their emotions and maintain a calm state may be better able attend to and process their surroundings cognitively. Likewise, children who are able to feel their emotions without being over- or under-controlled may experience more motivation to engage in cognitive tasks (e.g., experiencing desire of a reward may motivate a child put forth more effort in school). Conversely, EF influences ER by providing more cognitive mechanisms through which to regulate emotions. For example, the ability to reappraise a distressing situation as less negative (i.e., cognitive flexibility) can enable children to reduce negative emotions (Raver & Blair, 2016). It is through such bidirectional mechanisms that ER and EF are thought to promote the development of one another over time and become increasingly integrated.

There have been somewhat limited empirical examinations of ER–EF associations in early childhood, but there is some support for their bidirectional influences and integration. Generally, cross-sectional studies have found positive associations between ER and EF (Schmeichel & Tang, 2014). For example, Carlson and Wang (2007) found that observed inhibitory control and ER were positively associated among 4-6-year-old children. Similarly, Denham, Bassett, Zinsser, and Wyatt (2014) found that 3-5-year-old children's observed "hot" and "cool" EF abilities were positively associated—with hot EF reflecting emotionally salient or motivated challenges that require cognitive control cool EF reflecting challenges that require cognitive control, but have no emotional significance (Zelazo, 2015).

Longitudinal investigations have provided preliminary support for bidirectional effects of ER and EF in early childhood. Ferrier, Bassett, and Denham (2014) found that 3-5-year-old children's globally observed emotionality/ER in preschool classrooms predicted better teacher-reported EF six months later (but did not predict observed EF). Conversely, EF observed at the initial assessment predicted more positive emotionality/ER. However, their methods make it difficult to assess the specific role of ER, as opposed to emotion reactivity. In a recent study, Blankson and colleagues (2017) examined prospective associations among parent-reported ER, observed ER, and observed EF from 3 to 4 years old and found that parent-reported ER at age 3 predicted observed EF at age 4, but EF did not predict either measure of ER. However, EF was significantly correlated with both measures of ER at age 4.

Likewise, Ursache and colleagues used the current sample to observe infants' emotion reactivity and ER during stressful tasks at 7, 15, and 24 months as predictors of observed EF at 48 months of age (Ursache, Blair, Stifter, Voegtline, & The Family Life Project Investigators, 2013). They found that high levels of reactivity paired with higher levels of ER behavior at 15 months predicted better EF at 48 months. At low levels of reactivity, ER behavior did not predict EF, whereas moderate emotion reactivity predicted moderate EF, regardless of ER behavior. These findings demonstrate the complexity of interrelations among emotion, ER, and EF, while providing evidence that infants who are better able to mobilize ER strategies when they are highly distressed may be better equipped to regulate their cognitions years later. Although longitudinal investigations of ER–EF associations remain sparse, their individual and joint development in infancy and early childhood likely have important implications for the emergence and maintenance of ADHD, CPs, and CU behaviors.

Emotion Regulation and Executive Function Contributions to Conduct Problems, Attention-Deficit/Hyperactivity Disorder, and Callous-Unemotional Behaviors

Independently, deficits in both ER and EF have been proposed as etiological contributors to ADHD and CPs (Beauchaine & McNulty, 2013; Martel, 2009; Nigg & Casey, 2005; Shipman et al., 2004). For example, children who are unable to regulate feelings of anger may be more likely to respond to frustrating events with tantrums and/or aggression, and those who are unable to regulate excitement may respond to desirable stimuli with over-exuberance and hyperactivity. Such consistently poor ER over time, then, places children at risk for developing patterns of behavior representative of ADHD and CPs. Similarly, children who are unable to inhibit impulses are likely at greater risk for hyperactivity or aggression when they want something (e.g., becoming overly excited and forcibly taking a toy from another child, instead of waiting their turn). On the other hand, CU behaviors have been proposed to result partially from deficits in emotion reactivity, especially at the physiological level, rather than from ER and EF deficits (Frick et al., 2014). Specifically, low emotional reactivity is characteristic of the generally low emotionality shown by children with high CU behaviors, and may contribute to displays of low guilt and empathy for others, as low arousal makes the effects of their behavior on others less salient.

In a relatively comprehensive developmental model, Beauchaine and colleagues (Beauchaine, Hinshaw, & Pang, 2010; Beauchaine & Gatzke-Kopp, 2012; Beauchaine & McNulty, 2013) have suggested that early life impulsivity (characteristic of poor EF) and emotional lability and dysregulation are central to the emergence and maintenance of ADHD and CPs across childhood. They argue that early deficits in EF, emotion reactivity, and ER give rise to coercive parent–child interactions (Patterson, 1982; Patterson, DeGarmo, & Knutson, 2000), which reinforce cognitive and emotional deficits, ultimately canalizing the uninhibited, hyperactive, dysregulated, defiant, and/or aggressive behaviors that are characterized by ADHD and CPs. However, theirs and others' theoretical models have not considered the coaction and integration of ER and EF in the development of these psychopathologies. It is possible that examining longitudinal associations between ER and EF will present a more accurate description of developmental progressions toward CPs, and that the confluence of poor EF and ER may give rise to comorbid ADHD and CPs and/or more severe symptomology.

Independent associations of ER and EF with ADHD and CPs have been empirically tested extensively (less so for CU behaviors). In what have been primarily cross-sectional studies, ER has been significantly negatively associated with ADHD among children and adolescents (Anastopoulous et al., 2011; Lugo-Candelas, Flegenheimer, McDermott, & Harvey, 2017; Motamedi, Bierman, & Huan-Pollack, 2016; Sjöwall, Backman, & Thorell, 2015; Sjöwall, Roth, Lindqvist, & Thorell, 2013; Steinberg & Drabick, 2015). Indeed, a recent meta-analysis by Graziano and Garcia (2016) reported that emotion dysregulation and ADHD were strongly associated (d =

0.80). However, only one study, to my knowledge, has assessed the effects of ER on ADHD longitudinally beginning in early childhood. Sjöwall and colleagues found that parent-reported regulation of happiness/exuberance, but not anger, at 5 years old was negatively associated with ADHD symptoms at 18 years old (Sjöwall, Bohlin, Rydell, & Thorell, 2017).

Cross-sectional research on ER–CP links has demonstrated similar findings, with worse ER associated with greater CPs among children and adolescents (Bunford, Evan, & Langberg, 2018; Lugo-Candelas et al., 2017; Marsee & Frick, 2007; McQuade & Breaux, 2017; Siffert & Schwartz, 2011). Again, prospective studies have been lacking, but Bowie (2010) used an accelerated longitudinal design to examine ER and aggression from 5-14 years old and reported that girls self-reported ER when they were 5-12 years old was negatively associated with their relational aggression when they were 8-14 years old. However, girls' ER was not related to their overt aggression, and boys' ER was not predictive of either type of aggression.

Meta-analyses of cross-sectional EF studies have suggested that both inhibitory control and working memory are moderately negatively associated with ADHD among children and adolescents (Kasper, Alderson, & Hudec, 2012; Pauli-Pott & Becker, 2011). These associations have been frequently studied, but much of the existing research has focused on EF-ADHD links after early childhood (e.g., Antonini, Becker, Tamm, & Epstein, 2015; Bunford et al., 2015; Hudec et al., 2015; Kofler et al., 2018; Oosterlaan, Scheres, & Sergeant, 2005). However, a growing literature has examined early childhood EF and ADHD (Espy, Sheffield, Wiebe, Clark, & Moehr, 2011; Ezpeleta & Granero, 2015; Pauli-Pott, Schloß, & Becker, 2018; Schoemaker et al., 2012; Sjöwall et al., 2017; Skogan et al., 2015; Sonuga-Barke, Dalin, & Remington, 2003; Thorell & Wåhlstedt, 2006), with a handful of longitudinal studies showing expected results. For example, both Brocki et al. (2010) and Rabinovitz et al. (2016) found that inhibitory control at age 5 and/or 6 years was negatively associated with ADHD symptoms at age 7 (Brocki, Eninger, Thorell, & Bohlin, 2010; Rabinovitz, O'Neill, Rajendran, & Halperin, 2016). Similarly, Breaux, Griffith, and Harvey (2016) followed children from 3 to 6 years old and reported that better inhibitory control and working memory at age 3 predicted decreased likelihood of ADHD diagnosis at age 6.

Although less frequently studied that EF–ADHD links, EF has also been cross-sectionally related to CPs in childhood and adolescence (Finch & Obradović, 2017; Schoorl, van Rijn, de Wied, van Goozen, & Swaab, 2018; Ter-Stepanian et al., 2017; Thomson & Centifanti, 2018; Wang & Dix, 2017). Granero Louwaars, and Ezpeleta (2015) examined teacher-reports of 3-year-old children's EF and ODD symptoms and found that inhibitory control was negatively associated with ODD symptoms. To my knowledge, longitudinal influences of early EF on CPs have not been tested to date. Numerous studies, however, have assessed EF associations with either comorbid ADHD and CPs (either ODD or CD), or with ADHD and CP symptoms considered simultaneously. These have largely found that poor EF was associated with both ADHD and CPs, and their co-occurrence (Qian, Shuai, Cao, Chan, & Wang, 2010; Skogan et al., 2014; Speltz, DeKlyen, Calderon, Greenberg, & Fisher, 1999, van Goozen et al., 2004;

Xu, Jiang, Du, & Fan, 2017), but others have found that EF was associated with ADHD only (McQuade, Breaux, Miller, & Mathias, 2017; Thorell & Wåhlstedt, 2006).

Thus, findings across ER and EF research suggest, modestly, that ER and EF may be prospectively associated with ADHD and CPs. Their independent contributions are further supported by a recent study that simultaneously examined cross-sectional links of ER and EF with ADHD and CPs (Forslund, Brocki, Bohlin, Granqvist, & Eninger, 2016). They found that observed inhibitory control and parent-reported ER of positive emotions were negatively associated with ADHD symptoms, whereas ER of negative emotions was not associated with either ADHD or CP symptoms (EF–CP associations were not tested). Further, parent-reported positive emotionality (reflective of general emotion, including ER) was positively associated with ADHD symptoms, and negative emotionality was positively associated with CP symptoms. Nevertheless, there is a clear need for additional longitudinal investigations of ER and EF influences beginning in infancy and early childhood, including those that assess the interplay between ER and EF.

Behavioral and Physiological Reactivity in Relation to Emotion Regulation

The development of ER has clear relevance for multiple domains of functioning, including the emergence of CP, ADHD, and CU behaviors. However, ER occurs as part of a biopsychosocial process emotion process that involves both behavioral and physiological emotion reactivity. Engaging in ER likely has different implications for children who experience differing levels of reactivity. For example, children who show high behavioral and physiological fear reactivity in response to a stressor would likely benefit more from engaging in ER behaviors than children who are not highly aroused by such a stressor (Ursache et al., 2013). Measuring only ER behavior, then, may not provide a representative picture of children's emotion responding or their ability to self-regulate. Indeed, empirical associations among these aspects of emotion have been inconsistent (Lewis, 2011; Ursache et al., 2014), suggesting individual differences in children's patterns of emotion reactivity and regulation (Fox, Kirwan, & Reeb-Sutherland, 2012). Both behavioral emotion reactivity and physiological reactivity have been independently positively associated with ADHD (Graziano & Garcia, 2016; Lugo-Candelas et al., 2017; McQuade & Breaux, 2017; Northover, Thapar, Langley, Fairchild, & van Goozen, 2016) and CPs (Hastings, Fortier, Utendale, Simard, & Robaey, 2009; Winiarski, Engel, Karnik, & Brennan, 2018; Poon, Thurpyn, Hansen, Jacangelo, & Chaplin, 2016; Schoorl, van Rijn, de Wied, van Goozen, & Swaab, 2016; 2017). On the other hand, reactivity has generally been negatively associated with CU behaviors (Frick et al., 2014; Stadler et al., 2011). Thus, it is important to examine the heterogeneity in children's patterns of behavioral reactivity, physiological reactivity, and ER behaviors as they relate developmentally to EF, CPs, ADHD, and CU behaviors.

Current Study

The current study extends previous findings from Study 1 and Study 2 in order to assess the individual and joint influences of ER and EF in infancy and early childhood to trajectories of ADHD, CPs, and CU behaviors across childhood. Study 1 used latent profile analysis (LPA) to examine differential patterns of infants' behavioral reactivity, cortisol reactivity, and ER behavior in response to stress at 6, 15, and 24 months; and Study 2 used longitudinal latent class analysis (LCA) to examine joint trajectories of parent- and teacher-reported hyperactivity, CPs, limited prosocial behavior (proxy for CU behaviors) from 3 years old to 5th grade. The current study examined the prospective effects of infants' emotion response patterns at 24 months on their later CP/hyperactivity/limited prosocial behavior trajectories, mediated through their observed EF at 36, 48, and 60 months old (see Figure 7 for full conceptual model). In Study 1 at 24 months, infants' reactivity and regulation was characterized by four different profiles: (1) non-reactors (low behavioral reactivity, low/decreasing cortisol reactivity, moderate ER; 64.8% of the sample), (2) moderate asynchronous regulators (high behavioral reactivity, moderately low cortisol reactivity, high ER; 13.4%), (3) asynchronous regulators (moderate behavioral reactivity, low/decreasing cortisol reactivity, high ER; 12.6%), and (4) synchronous regulators (high behavioral reactivity, high cortisol reactivity, and high ER; 9.2%). In Study 2, children's CPs, hyperactivity, and limited prosocial behavior were characterized by four different trajectories: (1) stable low (as rated by both parents and teachers; 44.3%), (2) parent high decreasing (but stable low by teachers; 21.8%), (3) teacher increasing (but stable low by parents; 20.3%), and (4) stable high (as rated by both parents and teachers; 13.6%).

Based on the results from Studies 1 and 2, I hypothesized infants in the 'synchronous regulators' and 'moderate asynchronous regulators' profiles at 24 months would be more likely than the infants in the 'non-reactors' and 'asynchronous regulators' profiles to be in the 'stable high', 'parent high decreasing', and 'teacher increasing' trajectories across childhood, with the 'non-reactors' group showing the lowest likelihood of membership in those trajectories. Conversely, I hypothesized that the infants in the ‘non-reactors’ and ‘asynchronous regulators’ profiles would be more likely than the other two group to be in the ‘stable low’ trajectory, with the ‘non-reactors’ showing the greatest likelihood of membership in that trajectory. In addition, I hypothesized that these effects would be mediated by children’s EF averaged across 36, 48, and 60 months, with the ‘synchronous regulators’ and ‘moderate asynchronous regulators’ groups showing worse EF, which would then predict greater likelihood of showing ‘stable high’, ‘parent high decreasing’, and ‘teacher increasing’ trajectories and lower likelihood of showing the ‘stable low’ trajectory.

Methods

Participants

The Family Life Project is a large longitudinal study of children and families living in nonurban, lower income communities in the United States. Families and their newborns that lived in two major geographical areas of high child rural poverty (including three counties in eastern North Carolina and three counties in central Pennsylvania) were recruited using a stratified random sampling procedure yielding a representative sample of 1,292 families recruited over a one-year period at the time mothers gave birth to a child. The sample was recruited to be representative of every baby born to an English-speaking mother living in the counties selected during the year of recruitment, while also oversampling for poverty and race (i.e., African American). The full sample included 549 African American (42.5%) children, 736 European American (57%) children, 7 children of other race (0.5%), 657 girls (50.9%), and 635 boys (49.1%). See Willoughby and colleagues (2013) and Garrett-Peters and Mills-

Koonce (2013) for more information on the recruitment of the Family Life Project sample. Full-information maximum likelihood (FIML) estimation will be used to account for missing data and independent sample *t* tests will be estimated to compare mean differences on demographic measures between individuals who are missing data on all predictor variables and those with partial or complete data.

Procedures

Infants and families were visited for in-home data collection when the infants were 24, 36, 48, 60 months old, and in 1st grade. At the 24-month visit, primary caregivers (99.6% biological mothers) completed questionnaires on family demographics and child behavior, infants participated in a series of emotionally arousing challenge tasks, and parent–infant dyads completed a semi-structured play interaction together. The challenge tasks included a toy removal task followed by a scary mask task (Goldsmith & Rothbart, 1996). The current study uses infants' responses to the mask task because coincided with most children's peak reactivity in response to the challenge tasks (Ursache et al., 2014). In the mask task, four different masks were presented to the infant one at a time. The experimenter wearing the mask moved from side to side in front of the infant for 10 seconds while saying the infant's name. The primary caregiver was present in the room during the mask task, but did not interact with the child. Both tasks were video-recorded and coded second-by-second for infant reactivity and ER behaviors.

Three saliva samples were collected from infants in order to assess cortisol response to the emotionally arousing tasks. The first sample was a baseline sample collected before the tasks began, but after the researcher had been at the family's house for 1 hour. The second sample was collected approximately 20 minutes after the infant reached peak behavioral arousal, which was determined by the data collectors using clear guidelines established in the experimental protocol. Peak arousal for the great majority of infants occurred at the conclusion of the emotional challenge tasks (i.e., at the end of the mask task). Children who became highly aroused during the course of task administration as indicated by 20 seconds of hard crying, and who were determined to be too aroused for further task administration, were considered to have reached peak arousal. The third sample was collected 40 minutes after peak arousal. Unstimulated whole saliva was collected by using either cotton or hydrocellulose absorbent material and expressing the sample into 2 ml cryogenic storage vials using a needleless syringe (cotton) or by centrifugation (hydrocellulose). Two prior studies have indicated no differences in cortisol concentrations associated with the two collection techniques (Granger, Kivlighan, Fortunato, Harmon, Hibel, Schwartz, & Whembolua, 2007; Harmon, Granger, Hibel, & Rumyantseva, 2007). After collection, samples were immediately placed on ice, transported to interviewer's homes, and then stored frozen (–20°C).

At the 36-, 48-, and 60-month home visit, children spent between 30 and 45 minutes completing EF tasks. The tasks were presented in a flipbook format and consisted of measures of inhibitory control, working memory, and cognitive flexibility. For each of the six tasks, one research assistant administered training trials and up to three practice trials, if needed. If children failed to demonstrate an understanding of the goals of the task following the practice trials, the research assistant discontinued testing on that task. A second research assistant, who sat to the side and slightly behind the child, recorded all child responses to tasks into a laptop computer. Responses were scored during data processing. As is standard for executive function measures with children (Zelazo, 2006), children were required to successfully complete pretest trials in which they clearly demonstrated knowledge of the rules for the task and the ability to successfully complete the pretest trials as instructed. Children were also required to complete 75% of test trials in a given task in order to receive a score for that task. Full details of task administration and the creation of longitudinally scalable scores have been presented by Willoughby, Wirth, Blair, and The Family Life Project Key Investigators (2012).

When children were approximately 36 months old, teachers completed questionnaires about children's behavior on a yearly basis, until children were in 5th grade. Both parents and teachers completed the Strengths and Difficulties Questionnaire (SDQ), a brief screening questionnaire that includes subscales pertaining to children's CPs, hyperactivity, and prosocial behavior (Goodman, 1997). The SDQ uses 3-point Likert-type items to assess how true various statements are of the child (i.e., "not true", "somewhat true", "certainly true"). Parents completed the SDQ at the 36-month, 48-month, 60-month, and 1st grade home visits, whereas teachers completed it at the childcare, pre-K, Kindergarten, and 1st-5th grade school visits. Given that the home visits occurred within a year of the childcare (36 months), pre-K (48 months), Kindergarten (60 months), and 1st grade (1st grade home) school visits, these visits will be matched and considered as the same time point for the current study.

Measures

Negative behavioral reactivity. Reactivity was coded second-by-second from videos of mask and toy removal tasks for the total duration of the tasks. Reactivity was coded separately for each task. Three levels of negative emotional reactivity were coded: low reactivity including behaviors such as fussing, whining, frowning, furrowed brow, crinkled nose, slightly open or pressed lips; medium reactivity including crying, wide squared mouth, and eyes open or partially opened; and high reactivity including screams, wails, eyes partially or completely closed, and wide open mouth. Coders were trained to achieve .75 (Cohen's K) reliability. Interrater reliability for the mask task was calculated for at least 15% of completed cases and was high (K = .90). The proportion of time the child spent in mild, moderate, and highly negative reactive states during each task was calculated by dividing the number of seconds for each code by the total task duration. I calculated a mean intensity of negative reactivity score by multiplying the proportion of time the child spent in mild, moderate, and highly reactive states by 1, 2, and 3, respectively, then calculating a mean of those weighted intensity scores (Towe-Goodman et al., 2012).

Emotion regulation behaviors. Emotion regulation behaviors were coded second-by-second from video-recordings of each task by a separate team of coders. Specific behavioral codes were separated into three categories of non-overlapping ER strategies, based on past research (see Stifter & Braungart, 1995): (1) orienting regulation, which included the specific behaviors of orienting to the environment and looking to mother; (2) soothing/communication regulation, which included self-comforting, neutral vocalizations, gesture, and seeking comfort/contact; and (3) avoidance/active regulation, which included avoidance, tension reduction, and rejection. Within each category, only one specific behavior could be coded for at each second. Because a child could perform behaviors from multiple categories at the same time, however, each category was coded for by a separate team of coders. Thus, for each second of video, it was possible to have three regulation codes, but only one from each category. While all three categories were coded at each age, some of the specific regulation behaviors within categories were only coded later time points, in accordance with infant development and emergent skills (e.g., language acquisition and increased complexity of cognition).

Coders were trained to .75 (Cohen's K) reliability. Interrater reliability for the mask task was calculated on at least 15% of cases and ranged from .92–.97 across categories of regulatory behaviors. The proportion of time spent using each of these behaviors was calculated as the number of seconds for a specific behavior divided by the total duration of the task. The ER behavior variable for the current study represents the proportion of time that infants used regulatory behaviors during the task and was created by summing the proportion of time spent using each of the regulatory behaviors.

Salivary cortisol reactivity. Unstimulated whole saliva was collected by using either cotton or hydrocellulose absorbent material and expressing the sample into 2-ml cryogenic storage vials using a needleless syringe (cotton) or by centrifugation (hydrocellulose). All samples were assayed for salivary cortisol with a highly sensitive enzyme immunoassay (Salimetrics, State College, PA) that has been U.S. Food and Drug

Administration 510(k) cleared for use as an in vitro diagnostic measure of adrenal function. The test used 25 μl of saliva (for singlet determinations), had a range of sensitivity from 0.007 to 1.8 g/dl, and had average intra- and interassay coefficients of variation of <10% and 15%, respectively. All samples were assayed in duplicate. The criterion for repeat testing was variation between duplicates >20%, and the average of the duplicates was used in all analyses. Natural log transformations were applied to the cortisol values to correct for positive skew. Values >3 SD above and below the mean will be removed as outliers. Cortisol reactivity levels were calculated by subtracting the pre-task levels from the 20-minute post-peak arousal levels.

Executive function task descriptions. The EF battery consisted of seven tasks. Because these tasks have been previously described (Willoughby et al., 2012), I provide only abbreviated descriptions here.

Working memory span. This span-like task required children to perform the operation of naming and holding in mind two pieces of information simultaneously (i.e., the name of colors and animals in pictures of "houses") and to activate one of them (i.e., animal name) while overcoming interference occurring from the other (i.e., color name). Items were more difficult as the number of houses (each of which included a picture of a color and animal) increased.

Pick-the-picture game. This is a self-ordered pointing task presented to children with a series of two, three, four, and six pictures in a set. Children were instructed to continue picking pictures within each set until each picture had "received a turn". This task requires working memory because children have to remember which pictures in each item set they have already touched (spatial location of pictures changes across trials and was uninformative). This task was administered at the 48- and 60-month assessments.

Silly sounds stroop. This task presented children with pictures of cats and dogs and asked children to make the sound opposite of that which was associated with each picture (e.g., meow when showed picture of a dog). This task requires inhibitory control, as children have to inhibit the tendency to associate bark and meow sounds with dogs and cats, respectively.

Spatial conflict. This task presented children with a response card that had a picture of a car and boat. Initially, all test stimuli (pictures of cars or boats identical to that on the response card) were subsequently presented in locations that were spatially compatible with their placement on the response card (e.g., pictures of cars always appeared above the car on the response card). Subsequently, test items required a contralateral response (e.g., children were to touch their picture of the car despite the fact that it appeared above the boat). This task required inhibitory control, as children have to override the spatial location of test stimuli with reference to their response card.

Spatial conflict arrows. This task was identical in format to the spatial conflict task, with the exception that the response card consisted of two black dots (“buttons”) and the test stimuli were arrows that pointed to the left or right. Children were instructed to touch the button to which the arrow pointed. Initially, all left (right) pointing arrows pointed to the (left) right, but subsequently they pointed in the opposite direction. This task was administered at the 48- and 60-month assessments.

Animal go/no-go. This is a standard go/no-go task (e.g., Durston et al., 2002) presented in a flip-book format. Children are presented with a large button that clicks when pressed. They are instructed to click their button every time that they see an animal except when that animal is a pig. The examiner flips pages at a rate of one page per 2 s, with each page depicting a line drawing of one of seven possible animals. The task presents varying numbers of go trials prior to each no-go trial, including, in standard order, one-go, three-go, three-go, five-go, one-go, one-go, and three-go trials. Responses (correct, incorrect) to no-go trials were used for purposes of scoring. The no-go trials required inhibitory control.

Something's-the-same game. This task presented children with a pair of pictures for which a single dimension of similarity was noted (e.g., both pictures were the same color). Subsequently, a third picture was presented and children were asked to identify which of the first two pictures was similar to the new picture. This task required the child to shift his or her attention from the initial labeled to a new dimension of similarity (e.g., from color to size).

Executive function task scoring. As previously discussed (Willoughby et al., 2012), EF task scoring was facilitated by drawing a calibration sample of children, all of whom were deemed to have high-quality data (e.g., data collectors did not report interruptions, children completed multiple tasks). Graded response models were used to score the working memory span, which used polytomous item response formats, whereas two-parameter logistic models were used to score the remaining tasks (all of which involved dichotomous items response formats) in the calibration sample. The set of item parameters that was obtained from calibration sample was applied to all children's EF data, resulting in a set of item-response-theory-based (i.e., expected a posteriori [EAP]) scores for each task. Executive function summary scores were created by calculating a mean of all individual EF tasks within age, and then a mean of these scores was calculated to represent children's average EF across 36, 48, and 60 months. This method represents EF as a formative construct and has been shown to best represent children's EF performance in the current sample, compared to using individual EF scores and reflective summary scores (Willoughby et al., 2012; Willoughby, Blair, and The Family Life Project Key Investigators, 2016).

Conduct problems. Children's conduct problems were measured at each home- and school-visit using the conduct problems subscale of the SDQ. The subscale includes five items: (1) "often loses temper"; (2) "generally well behaved, usually does what adults request (reverse scored)"; (3) "often fights with other children or bullies them"; (4) "often lies or cheats"; and (5) "can be spiteful to others". In order to index clinically relevant levels of CPs, the normed cutoffs for children in the United States (see http://www.sdqinfo.com/norms/USNorm.html) will be used to create a dichotomous variable denoting CP scores below the 90th percentile and those at or above that cutoff.

Hyperactivity. Children's hyperactivity was measured at each home- and school-visit using the hyperactivity subscale of the SDQ. The subscale includes five items: (1) "Restless, overactive, cannot stay still for long"; (2) "Constantly fidgeting or squirming"; (3) "Easily distracted, concentration wanders"; (4) "Thinks things out before acting", and (5) "Good attention span, sees work through to the end". As with CPs, the

US normed cutoffs will be used to create a dichotomous variable denoting scores below the 90th percentile and those at or above that cutoff.

Limited prosocial behavior. Children's limited prosocial behavior was measured at each home- and school-visit using the prosocial behavior subscale of the SDQ. The subscale includes five items: (1) "Considerate of other people's feelings"; (2) "Shares readily with other children, for example toys, treats, pencils"; (3) "Helpful if someone is hurt, upset or feeling ill"; (4) "Kind to younger children"; and (5) "Often offers to help others (parents, teachers, other children)". In order to index *limited* prosocial behavior, the US normed cutoffs will be used to create a dichotomous variable denoting scores at or below the 10th percentile and those above that cutoff. Children scoring at or below the 10th percentile will be labeled as showing limited prosocial behaviors.

Covariates. Child gender, child race, and primary caregivers' years of education were reported by primary caregivers when they were recruited at the time of their child's birth (and confirmed at each home visit). Family income-to-needs ratio (total household income divided by the 2005 federal poverty threshold) was reported by primary caregivers when children were 24, 36, 48, 60, and 90 months old; the mean income-to-needs ratio across these visits were used for the current analyses. The time of day at which children provided baseline saliva samples at each visit was recorded in order to account for variations in cortisol that may be the result of diurnal rhythms (Gunnar & Adam, 2012).

Analysis Plan

In Study 1, LPA was used to identify groups of infants with similar patterns of behavioral reactivity, cortisol reactivity, and ER behaviors in response to the challenge tasks at 24 months. Likewise, Study 2 used LLCA to identify groups of children with similar trajectories of CPs, hyperactivity, and limit prosocial behavior from 3 years old to 5th grade. In the current study, I used latent transition analysis (LTA), another latent variable method similar to logistic regression that tests the prediction of membership in one mixture model based on membership in another mixture model (Lanza et al., 2010). In addition, I tested whether the effects of infant emotion responding on CP/hyperactivity/limited prosocial behavior trajectories were mediated by children's EF averaged across 36, 48, and 60 months old. All models were fit using Mplus 8 (Muthén & Muthén, 1998–2017). Mediation was assessed with indirect effects, as recommended by MacKinnon and Pirlott (2015). Missing data were handled using full information maximum likelihood methods (Enders & Bandalos, 2001). Given the stratified random sampling design, a robust maximum likelihood estimator (MLR) was used to estimate all models to allow for inclusion of individual probability weights associated with oversampling of low-income and African American families and stratification on income, state, and race. The previously mentioned covariates were included in all structural models. First, an unconditional LTA model was analyzed in order to assess the probability of membership in each trajectory based on membership in the emotion profiles without the presence of covariates or the EF mediator in the model. Next a conditional LTA model that included all covariates and EF, was analyzed to examine prediction of the trajectories and mediation through EF. Model fit was assessed using the Bayesian information criteria (BIC) and sample size-adjusted Bayesian information criteria (ssBIC; Henson, Reise, & Kim, 2007; Nylund, Asparouhov, & Muthén, 2007).

Results

Descriptive Statistics

Table 12 presents the bivariate correlations among the central study variables and covariates, as well as the means and standard deviations of each variable. As in Study 2, means of CPs, hyperactivity, and limited prosocial behavior from 3 years old to 5th grade were computed to provide a general sense of their correlations with other variables. Neither 24-month behavioral reactivity, cortisol reactivity, nor ER were significantly correlated with later EF, CPs, hyperactivity, or limited prosocial behavior. However, EF showed small-to-moderate negative correlations with CPs, hyperactivity, and limited prosocial behavior.

Latent Transition Analysis

Unconditional model. Before assessing the effects of emotion profile group membership on CP/hyperactivity/limited prosocial behavior trajectory membership and testing EF as a mediator of such effects, an unconditional LTA model was fitted to assess the transition probabilities of each of the emotion profiles. Table 13 presents, for each 24-month emotion profile, the probability of being in each CP/hyperactivity/limited prosocial behavior trajectory. For all four emotion profiles, the most likely trajectory to enter was the ‘stable low’ trajectory. However, most children within each emotion profile exhibited one of the other three behavioral trajectories (e.g., 57% combined for the ‘non-reactors’ group).

Conditional model with executive function and covariates. The LTA model examined whether 24-month emotion profile group membership predicted CP/hyperactivity/limited prosocial behavior trajectory membership, and whether any such associations were mediated by EF. Across all pairwise group comparisons, infants’ emotion profile membership did not significantly predict their later CP/hyperactivity/limited prosocial behavior trajectories, with one exception. Infants in the ‘asynchronous regulators’ group at 24 months were more likely than those in the ‘non-reactors’ group to follow the ‘teacher increasing’ trajectory than the ‘parent high decreasing’ trajectory, b = 1.10, SE = 0.54, $p = .040$. Given these largely null results, a second conditional LTA model that excluded the effects of the emotion profiles on the CP/hyperactivity/limited prosocial behavior trajectories, but retained all other effects. This revised model fit the data better than the original conditional model (BIC = 17486.08 vs. 17539.83; ssBIC = 17374.90 vs. 17400.07), indicating that membership in emotion profiles did not significantly predict membership in the CP/hyperactivity/limited prosocial behavior trajectories. Therefore, the revised conditional LTA model was retained.

Table 14 presents the longitudinal effects of emotion profile membership on EF, as well as of EF on membership in the CP/hyperactivity/limited prosocial behavior trajectories. Emotion profile membership did not significantly predict EF in early childhood. However, EF did significantly predict membership in the

CP/hyperactivity/limited prosocial behavior trajectories. Specifically, a one point increase in children's EF scores was associated with a 15.63, 3.9, and 4.5 times greater likelihood of being in the 'stable low' trajectory versus the 'stable high', 'parent high decreasing', and 'teacher increasing' trajectories, respectively. Thus, the children who scored at the mean on EF were almost 30, 8, and 9 times more likely, respectively, to show no problem behaviors over time than the children in the sample who had the lowest EF scores. Further, a one point increase in EF was associated with a 3.98 times greater likelihood of being in the 'parent high decreasing' trajectory, and a 3.45 times greater likelihood of being in the 'teacher increasing' trajectory, compared to the 'stable high' trajectory. However, early childhood EF was not associated with differences between the 'parent high decreasing' and 'teacher increasing' groups. Of course, given that emotion profile membership did not predict either EF or CP/hyperactivity/limited prosocial behavior trajectory membership, the indirect effect of the emotion profiles on the CP/hyperactivity/limited prosocial behavior trajectories was not significant, b = 0.001, SE = 0.01, p = .902.

Discussion

The current study examined whether 24-month-old infants' profiles of behavioral reactivity, cortisol reactivity, and ER predicted their trajectories of CPs, hyperactivity, and limited prosocial behavior from 3 years old to 5th grade; and whether EF during early childhood mediated any such associations. Inconsistent with expectations, infant's emotion profile membership, for the most part, did not significantly predict trajectory membership. Further, emotion profile membership did not predict EF. Consistent with hypotheses, though, EF did significantly predict trajectory membership, with better EF being associated with a greater likelihood of membership in the 'low stable' group compared to all other groups; and the 'parent high decreasing' and 'teacher increasing' groups relative to the 'stable high' group.

Emotion Responding and Trajectories of Conduct Problems, ADHD Symptoms, and CU Behaviors

To my knowledge, the current study is the first to examine longitudinal associations between differential profiles of emotion responding in infancy and joint trajectories of CPs, ADHD symptoms, and CU behaviors (or limited prosocial behavior as a proxy of CU behaviors) across childhood. Although the existing research on independent links of ER with CPs, ADHD, and CU behaviors is limited, previous findings suggested that infants' patterns of behavioral reactivity, cortisol reactivity, and ER may be linked to their later behavioral trajectories. However, I found no support for such longitudinal associations. Although deficits in ER have been implicated as potential contributors to the development of CPs, ADHD, and CU behaviors (Beauchaine & McNulty, 2013), children typically show rapid improvements in their ER abilities across childhood (Sameroff, 2010). It is possible that heterogeneity in emotion reactivity and regulation at one point in infancy cannot explain variation in trajectories of CPs, ADHD symptoms, and CU behaviors that span early and middle childhood because children make such large skill gains over that time period.

Beyond ER skills, children normatively develop more complex abilities across emotional, cognitive, and behavioral domains (Lerner, 2015) during early childhood that, for many children, likely buffer against early deficits in reactivity and regulation. Therefore, it may be that the 24-month emotion profiles do not delineate groups of infants showing severe enough difficulties with reactivity and ER to confer risk for stable, long-term problem behavior. Alternatively, the persistence of reactivity and ER difficulties beyond infancy may better predict stable problem behavior. As noted in Study 1, most infants stayed in, or transitioned into, the 'non-reactors' group over time. The infants who remain in the 'synchronous regulators' group into early childhood, though, may be at greater risk for stable high CPs, ADHD, and CU behaviors across childhood. However, such a hypotheses will need to be tested in future studies.

Emotion Responding and Early Childhood Executive Function

This is also one of the first studies, to my knowledge, to examine longitudinal associations between emotion responding and EF during infancy and early childhood. Although emotion profile membership was expected to predict EF, the lack of association may, again, be due to the rapid development of multiple competencies shown by children during early childhood. For example, improvements in attentional control may have a stronger influence on early EF abilities (Garon et al., 2008). However, attention is thought to promote both ER and EF development in early life (Calkins & Marcovitch, 2010; Bell & Deater-Deckard, 2007; Rothbart, Posner, & Kieras, 2006). Empirical studies have shown moderate support for associations of attention with both, but most have been cross-sectional (Calkins, Dedmon, Gill, Lomax & Johnson, 2002; Graziano, Calkins, & Keane, 2011; Johansson, Marciszko, Brocki, & Bohlin, 2016; Johansson, Marciszko, Gredebäck, Nyström, & Bohlin, 2015). Thus, further investigations of attention development may be helpful in clarifying the potential association and integration of ER and EF during early childhood.

Alternatively, the lack of associations between patterns of emotion responding and EF in the current study may be explained by the mismatch in emotional salience of the infant challenge tasks and the EF tasks in early childhood. The EF tasks used reflect what Zelazo (2015) has termed “cool” EF because they lack emotion salience for the children completing them. Since the tasks provide no emotional significance for children, their emotional functioning may have little influence on their ability to perform well. However, “hot” EF tasks that have emotional significance for children require an integration of ER and EF (either using ER to aid completion of a cognitively demanding tasks or using EF abilities to regulate emotions; Carlson & Wang, 2007; Zelazo, 2015). Therefore, variations in infants’ emotion responding during infancy may have stronger influences on “hot” EF than “cool” EF. Future studies that utilize both types of EF tasks are needed in order to test such differential prediction of emotion functioning.

Executive Function and Trajectories of Conduct Problems, ADHD Symptoms, and CU Behaviors

Previous research has shown modest associations between EF and CPs and ADHD, but the current study is the first to examine such associations longitudinally, and to include a proxy of CU behaviors, as well. In addition, the current study is the first to test the effects of EF on childhood trajectories of these behaviors. Thus, poorer EF was predictive of consistently high CPs, hyperactivity, and limited prosocial behavior over several years of childhood. These findings provide further evidence that the development of EF abilities are an important task of early childhood that has implications for children's downstream functioning (Calkins, 2007), as children with lower EF scores were several times more likely to be in any of the three groups other than the 'stable low' group compared to children with higher EF scores. Although these findings do suggest that poor EF early in life can have quite negative implications for functioning across childhood, they also provide further support for children's EF as a focus of potential prevention and intervention efforts. Several interventions focused on young children's self-regulatory skills, and EF in particular, have already been developed, and have shown positive results in improving EF, behavioral adjustment, and school readiness and achievement (Graziano & Hart, 2016; Riggs, Greenberg, Kusché, & Pentz, 2006; Ursache, Blair, & Raver, 2012). Based on the large effects of EF in the current study, it is possible that administering such interventions in early childhood could have strong buffering effects against persistent problem behavior across childhood, if they are effective in improving children's EF abilities. However, further research is needed to replicate the longitudinal effects of EF on trajectories of CPs, ADHD, and CU behaviors found in the current study; as well as to determine whether existing or new self-regulation interventions are able to improve behavioral outcomes over the course of childhood.

Strengths and Limitations

The current study has at least four key strengths. First, the use of a prospective longitudinal design allowed for the prediction of EF and problem behaviors from infant emotion responding, as well as the observation of CP/hyperactivity/limited prosocial behavior trajectories across several years of childhood. Second, observational measures were used to observe behavioral reactivity, ER, and EF, as opposed to parent reports; and these observational measures were conducted in families' homes, increasing their ecological validity versus lab-based tasks. Third, the collection of simultaneous behavioral reactivity, cortisol reactivity, and ER behavior allowed me to assess the influence of their joint activation on later functioning, rather than examining them individually, as has been done in most previous studies. Finally, both parents and teachers rated children's CPs, hyperactivity, and limited prosocial behavior at multiple time points, which allowed for the detection of differences in children's behavior across context.

However, the current study also had at least four limitations. First, in order to improve interpretability of the emotion profiles, I used a difference score to compute cortisol reactivity, which is not the current best practice, but doing so was likely the best method for the current application (see Study 1). Likewise, I used a mean score of various ER behaviors to make interpretation easier, whereas an examination of specific ER behaviors may be beneficial for understanding ER in isolation during infancy. Second, parents only reported on the SDQ at four of the seven time points included in the final estimation of the CP/hyperactivity/limited prosocial behavior trajectories. Having parent reports at all time points would have provided more strength to the conclusions regarding reporter differences on the trajectories. Third, the current sample did not have formal measures of CU behaviors throughout childhood, meaning the prosocial scale of the SDQ needed to be used as a proxy measure. Although the items on the prosocial scale are not specifically designed to measure CU behaviors, they are similar to some items on CU scales. Further, the 10th percentile cutoff likely identified children who showed very low amounts of prosocial behavior, which is similar to the limited prosocial emotions described in the DSM-5. Finally, it should be noted that LPA and LLCA are data-driven methods, for which the fit indices almost always suggest that more than one class should be extracted. Therefore, caution should be used when interpreting the results because they may or may not represent the true nature of the data (Bauer & Curran, 2003). Nevertheless, the emotion profiles and trajectories used in the current study are consistent with existing theoretical and empirical work, and EF showed effects on the trajectories in the expected direction. Thus, I have confidence that the results of these person-centered methods are likely accurate representations of the data.

Conclusion

The current study examined the longitudinal effects of infants' emotion responding to stressful stimuli on their childhood trajectories of CPs, ADHD symptoms, and CU behaviors, mediated through early childhood EF. Although infant emotion responding did not predict either problem behavior trajectories or EF, EF was strongly associated with the behavioral trajectories. The methods used herein were innovative on multiple fronts, including the modeling of heterogeneity using a person-centered approach and testing longitudinal associations among emotion responding, EF, and problem behaviors, which have largely been assessed cross-sectionally in past research. The results demonstrate that early life EF can have powerful consequences for children's behavior over time, even into preadolescence. However, continued basic and applied research offers the opportunity to better understand the developmental processes tested here and to improve children's EF and prevent or treat CPs, ADHD, and CU behaviors.

CHAPTER V

GENERAL DISCUSSION

The three studies herein applied innovative analytic methods in an attempt to better understand early emotion functioning and the course of conduct problems, as well as how the two are developmentally linked. As noted previously, a major question among researchers studying early emotion development is the degree to which behavioral and physiological arousal and regulation are interrelated. Study 1 was one of the first, to my knowledge, to bring data to bear on this unresolved question. The results provide support for the hypothesis that inconsistent correlations between emotion reactivity and regulation are the result of heterogeneity in infants' levels of these emotion responses (Fox et al., 2012). It may be important, then, for researchers to consider such heterogeneity in order to better understand early emotion functioning, whether through person-centered methods or moderation analyses. Of course, the findings from Study 1 were sample-specific and require replication in other samples in order to determine whether similar heterogeneity can be found, and whether different profiles of emotion responding will emerge.

In addition, the question remains as to the conditions under which individual emotion profiles are more or less adaptive than others. For example, the prevalence of the 'non-reactors' group across age suggests that it may be the most normative (and, possibly, most adaptive) profile in response to the mild challenge tasks used in the study.

Conversely, more harsh-intrusive parenting was predictive of membership in the 'synchronous regulators' group. Given the associations of harsh-intrusive parenting with various negative outcomes for children (Chang, Schwartz, Dodge, & McBride-Change, 2003; Conger, Schofield, Neppl, & Merrick, 2013; Waller et al., 2012), emotion responding characteristic of the 'synchronous regulators' may be maladaptive in across situations that young children typically face. Future investigations are needed to determine whether these profiles are predictive of differential functioning across various domains, and whether such differences persist depending on the setting and task at hand.

Beyond further replicating and testing the emotion profiles found in Study 1, another frontier in need of study is the match and mismatch of other aspects of emotion responding not included in Study 1. For example, the ways in which HPA axis, sympathetic nervous system, and parasympathetic nervous system activity operate in synchrony or asynchrony remains unknown (Dennis et al., 2012). Likewise, modeling the coaction of behavioral reactivity, neural activity, and ER behavior may provide an opportunity to understand how young children learn to engage in cognitive ER strategies. As children grow in their ER capacities, it becomes increasingly likely that they use cognitive control to help regulate their emotions (e.g., reappraisal; Raver & Blair, 2016) and evidence few, if any, behavioral manifestations of ER (Simonds et al., 2007). Thus, behavioral observations of ER become increasingly incapable of distinguishing between a lack of reactivity and the successful use of cognitive ER strategies. However, the simultaneous observation of behavioral reactivity, neural activity (e.g., via event-related potentials), and ER behaviors may allow for inferences about the use of cognitive ER strategies based on activation in brain regions associated with ER. Infants and children likely show significant variation in emotion responding across these various levels of analysis, indicating that there is much to be learned from examining them together in multiple combinations.

Another important developmental question addressed in the current dissertation is what factors contribute to variation in childhood trajectories of CPs. To my knowledge, Study 2 was the first to examine joint trajectories of CPs, hyperactivity, and limited prosocial behavior (as a proxy of CU behaviors). Interestingly, I did not find trajectories of CPs that were differentiated by levels of ADHD and/or limited prosocial behavior. Rather, parent- and teacher-reports differentiated children's trajectories of all three behaviors, suggesting that more severe problem behaviors may be characterized by presence in both home and school settings over time, with less severe problems presenting in a single context. Although setting helped delineate heterogeneity in these behaviors over time, the question remains as to whether ADHD and CU behaviors can help explain CP trajectories. Based on the extensive theoretical literature, ADHD and CU behaviors do likely represent etiological factors that contribute to the emergence and stability of CPs over time, despite the findings from Study 2. In order to further test joint trajectories of these psychopathologies, replication efforts are needed. The use of clinical samples; more intensive measures of CPs, ADHD, and CU behaviors than the SDQ; and/or novel modeling techniques may in such studies may increase the likelihood of detecting CPs that vary based on ADHD and CU behaviors.

Study 3 addressed the final goal of the current dissertation by assessing the developmental link between infant emotion functioning and childhood trajectories of CPs, hyperactivity, and limited prosocial behavior. Infants' profiles of emotion responding were not associated with their later problem behavior trajectories. However, given that ER has been implicated in various forms of psychopathology, including CPs and ADHD (Beauchaine & McNulty, 2013; Nigg & Casey, 2005; Shipman, Schneider, & Brown, 2004), further longitudinal investigations are needed. Specifically, assessing emotion responding beyond infancy, into early childhood, may be necessary for predicting CP/ADHD/CU trajectories that span much of childhood, given the rapid development of emotional, cognitive, and behavioral competencies early in life (Lerner, 2015).

Also in Study 3, I did not find prospective effects of infant emotion responding on early childhood EF, which may be due to buffering by other competencies or the mismatch in emotional salience of the challenge and EF tasks used in the study. However, these aspects of self-regulation are not only important for various child outcomes (Calkins, 2007; Morrison et al., 2010), but also seem to become integrated over time (Calkins & Marcovitch, 2010). Notably, results from Study 3 showed that better early-childhood EF buffered against trajectories of elevated CPs, hyperactivity, and limited prosocial behavior. Therefore, future research that can better account for potentially confounding influences on both emotion and EF (e.g., attention) and for the influence of emotional salience of specific tasks will be useful in clarifying the links between emotion responding and EF, as well as the implications of their interplay for psychopathological outcomes. These efforts will be further bolstered in studies that include measures of emotion and EF simultaneously over time, which will allow for the assessment of prospective, bidirectional effects.

An important common thread across all three studies is the use of innovative person-centered methods to address unanswered questions about self-regulatory and psychopathological development. Though not all of my hypotheses were supported, these studies demonstrate the utility of a person-centered approach for understanding development in unique ways. Latent profile analysis and latent class analysis provided the opportunity to assess unobserved variation in children's behavior and physiology across several observed indicators that, otherwise, would not be attainable. Latent transition analysis, in turn, enabled me to examine stability and change in such variation among children, and to prospectively psychopathological trajectories. As noted previously, these techniques can be useful in continued efforts to understand early self-regulatory and psychopathological development. Of course, person-centered approaches are not the solution to all methodological problems in these area of research. Rather, a combination of both person- and variable-centered methods within and across studies will likely lead to the most fruitful discoveries.

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APPENDIX A

TABLES AND FIGURES

Table 1. Expected Profiles of Behavioral Reactivity, Cortisol Reactivity, and Emotion Regulation Behavior

	Behavioral reactivity	ER	Cortisol reactivity	Likelihood at each Age
1. Non-Reactors	Low	Low	Low	6m = 15m = 24m
2. Synchronous Reactors	High	Low	High	6m = 15m = 24m
3. Asynchronous Reactors	High	Low	low	6m = 15m = 24m
4. Synchronous Regulators	High	High	High	6m > 15m > 24m
5. Asynchronous Regulators	Moderate/High	High	Low	6m < 15m < 24m
6. Suppressors	Low	Low/Moderate	High	6m < 15m < 24m

Note. 6m = 6 months old; 15m = 15 months old; 24m = 24 months old

Table 2. Study 1 Bivariate Correlations

	1	2	3	4	5	6	7	8	9	10	11	12
1. Child race[a]	–											
2. Child sex[b]	.00	–										
3. State[c]	-.50**	-.08**	–									
4. Income-to-needs	-.33**	-.04	.17**	–								
5. Parent education	-.24**	.00	.16**	.62**	–							
6. Behav. react. (6m)	-.08*	.05	-.02	.10**	.06	–						
7. Behav. react. (15m)	.09**	.07	-.08*	-.05*	-.04	.04	–					
8. Behav. react. (24m)	.10**	-.04	.02	-.10	-.12**	.06	.39**	–				
9. Cort. react. (6m)	-.08**	.05†	.07*	.03**	.03	.12**	.05	.07	–			
10. Cort. react. (15m)	-.08**	.06	.05	-.02	.03	.03	.22**	.12**	.03	–		
11. Cort. react. (24m)	.05	.00	-.08*	-.08	-.04	.01	.16**	.25**	-.04	.10*	–	
12. ER (6m)	-.02	-.04	.04	-.05*	-.02	-.08*	-.04	-.02	.01	.03	-.03	–
13. ER (15m)	.03	.12**	-.06	.02	.06	.10*	.30**	.11**	.02	.04	.01	.04
14. ER (24m)	.01	.04	.03	.11*	.01	.10*	.28**	.37**	.11**	.05	.12**	.00
15. Baseline time (6m)	-.07**	-.03	.00	.16**	.10**	.12**	-.01	-.02	-.03	-.02	-.03	-.06
16. Baseline time (15m)	-.04	-.05	-.01	.18**	.11**	.10**	-.01	-.06	-.05	-.03	.01	.01
17. Baseline time (24m)	-.11**	.00	.11**	.21**	.19**	.04	-.05	-.04	.03	.00	.05	.03
18. Sensitivity (6m)	-.31**	.04	.18**	.33**	.41**	.05	.02	-.06†	.09**	-.02	-.03	-.01
19. Harsh-Intrusion (6m)	.33**	-.06†	-.21**	-.26**	-.26**	-.07*	.09*	.09**	.00	.00	.05	.00
20. Sensitivity (15m)	-.30**	.00	.19**	.43**	.49**	.09*	.00	-.09*	.08*	.02	-.09**	.02
21. Harsh-Intrusion (15m)	.24**	-.03	-.13**	-.27**	-.34**	-.10**	.08*	.12**	-.02	-.05	.08*	.02
22. Sensitivity (24m)	-.33**	-.01	.15**	.41**	.48**	.07†	.00	-.11**	.05	.08*	-.04	.00
23. Harsh-Intrusion (24m)	.31**	-.07*	-.19**	-.31**	-.35**	-.09*	.05	.09**	.00	-.07*	.05	-.03
Number	1239	1239	1239	1236	1292	875	903	826	1007	902	896	882
Mean	0.23	0.48	0.59	2.16	13.02	0.25	0.20	0.25	0.10	0.19	-0.04	0.50
Standard deviation	0.42	0.50	0.49	1.57	2.22	0.23	0.21	0.27	0.75	0.68	0.72	0.30

Note. Behav. react. = Behavioral reactivity, Cort. react = Cortisol reactivity, ER = Emotion regulation, Baseline time = time of day baseline cortisol was collected, 6m = 6 months old, 15m = 15 months old, 24m = 24 months old

[a] 0 = European American, 1 = African American. [b] 0 = male, 1 = female. [c] 0 = North Carolina, 1 = Pennsylvania

* $p < .05$, ** $p < .01$, † $p < .10$

Table 2 (continued)

	13	14	15	16	17	18	19	20	21	22	23
13. ER (15m)	–										
14. ER (24m)	.13**	–									
15. Baseline time (6m)	.07†	.00	–								
16. Baseline time (15m)	.03	.06	.26**	–							
17. Baseline time (24m)	.00	-.03	.22**	.23**	–						
18. Sensitivity (6m)	.06	.04	.04	.01	.15**	–					
19. Harsh-Intrusion (6m)	.00	.08*	.00	-.03	-.07*	-.18**	–				
20. Sensitivity (15m)	.09**	.06	.05	.10**	.15**	.64**	-.18**	–			
21. Harsh-Intrusion (15m)	.00	.01	-.01	-.05	-.10**	-.24**	.39**	-.36**	–		
22. Sensitivity (24m)	.06†	.03	.11**	.10**	.15**	.53**	-.23**	.64**	-.33**	–	
23. Harsh-Intrusion (24m)	.01	-.03	-.07*	-.08*	-.08*	-.24**	.35**	-.36**	.41**	-.55**	–
Number	911	839	1192	1168	1135	1141	1141	1100	1100	1055	1055
Mean	0.22	0.56	4.92	5.09	5.16	3.04	2.28	2.93	2.17	3.05	2.28
Standard deviation	0.24	0.47	1.07	1.12	1.27	0.76	0.70	0.79	0.66	0.80	0.83

Note. Behav. react. = Behavioral reactivity, Cort. react = Cortisol reactivity, ER = Emotion regulation, Baseline time = time of day baseline cortisol was collected, 6m = 6 months old, 15m = 15 months old, 24m = 24 months old

[a] 0 = European American, 1 = African American. [b] 0 = male, 1 = female. [c] 0 = North Carolina, 1 = Pennsylvania

* $p < .05$, ** $p < .01$, † $p < .10$

Table 3. Fit Statistics for Latent Class Analysis Models of Conduct Problems, Hyperactivity, and Limited Prosocial Behavior

Number of classes	BIC	ssBIC	aVLMR	Entropy
6 months				
2	2394.24	2362.48	p < .001	.694
3	2332.65	2288.18	p = .173	.674
4	**2252.35**	**2195.18**	***p* = .012**	**.723**
5	2254.45	2184.57	p = .151	.752
6	2254.24	2171.65	p = .526	.699
7	2246.21	2150.92	p = .668	.712
15 months				
2	1312.65	1280.89	p < .001	.797
3	1150.61	1106.16	p = .011	.826
4	1041.50	984.33	p = .002	.814
5	**993.61**	**923.73**	***p* = .281**	**.784**
6	942.41	859.83	p = .130	.796
7	894.48	799.19	p = .080	.781
24 months				
2	2872.55	2840.79	*p < .001*	.744
3	2683.58	2639.12	*p < .001*	.765
4	**2555.19**	**2498.01**	***p* = .009**	**.775**
5	2493.38	2423.51	p = .304	.768
6	2416.16	2333.58	p = .023	.781
7	2388.25	2292.97	p = .146	.777

Note. BIC = Bayesian information criteria; ssBIC = Sample size-adjusted Bayesian information criteria; aVLMR = Adjusted Vuong-Lo-Mendell-Rubin likelihood ratio test
Bold indicates the final model selected based on theory, interpretability, and fit indices.

Table 4. Comparison of Hypothesized Emotion Profiles to the Estimated Latent Profiles

Hypothesized Profile	LPA Support	LPA Discrepancies from Hypothesized Groups	LPA Group Name
(1) Low behavioral reactivity, low cortisol reactivity, low ER	Partial	This group was found at 15 months. At 6 and 24 month, the groups showing low behavioral and cortisol reactivity showed moderate ER	Low Reactors
(2) High behavioral reactivity, high cortisol reactivity, low ER	Partial	This group was found at 15 months, but not 6 or 24 months	Synchronous Reactors
(3) High behavioral reactivity, low cortisol reactivity, low ER	None	This group was not found at any age	Asynchronous Reactors
(4) High behavioral reactivity, high cortisol reactivity, high ER	Partial	This group was found at all ages, but at 6 months, this group showed moderately high ER	Synchronous Regulators
(5) Moderate/high behavioral reactivity, low cortisol reactivity, high ER	Partial	This group was found at 6 and 24 months, but not at 15 months. A moderate asynchronous regulator group was also found at 6 and 24 months	Asynchronous Regulators
(6) Low behavioral reactivity, high cortisol reactivity, low ER	None	This group was not found at any age	Suppressors

Note. LPA = Latent profile analysis, ER = Emotion regulation

Table 5. Estimated Transition Probabilities of Changing Profiles Across 6, 15, and 24 Months Old

	6 months				**15 Months**				
	Non-React.	Mod. Async. Reg.	Async. Reg.	Sync. Reg.	Non-React.	Sync. React.	Mod. Sync. Reg.	Sync. Reg.	Low React. Reg.
15 Months									
Non-React.	0.56	0.62	0.55	0.42		–	–	–	–
Sync. React.	0.22	0.09	0.26	0.21		–	–	–	–
Mod. Sync. Reg.	0.12	0.20	0.09	0.14		–	–	–	–
Sync. Reg.	0.09	0.04	0.08	0.18		–	–		–
Low React. Reg.	0.03	0.05	0.03	0.06		–	–	–	–
24 months									
Non-React.	0.62	0.54	0.50	0.45	0.65	0.41	0.65	0.18	0.59
Mod. Async. Reg.	0.14	0.20	0.20	0.20	0.16	0.19	0.14	0.30	0.14
Async. Reg.	0.14	0.14	0.18	0.29	0.16	0.19	0.15	0.15	0.21
Sync. Reg.	0.11	0.12	0.12	0.06	0.05	0.22	0.06	0.37	0.08

Note. Non-React. = Non-reactors, Mod. Async. Reg. = Moderate Asynchronous Regulators, Async. Reg. = Asynchronous Regulators, Sync. Reg. = Synchronous Regulators, Sync. React. = Synchronous Reactors, Mod. Sync. React. = Moderate Synchronous Reactors, Low React. Reg. = Low Reactive Regulators. The transition probabilities for each group do not always add to exactly 1, due to rounding error.

Table 6. Robust Maximum Likelihood Estimates of Parenting Effects on 15- and 24-Month Emotion Profiles

Parameter	Effects			
	b	SE	Odds Ratio	95% CI
15 months (Non-React. Reference)				
6m Sensitivity → Sync. React.	0.23	0.17	1.26	0.91 – 1.75
6m Harsh-Intrusion → Sync. React.	0.11	0.17	1.11	0.79 – 1.56
6m Sensitivity → Mod. Sync. Reg.	0.23	0.28	1.26	0.73 – 2.18
6m Harsh-Intrusion → Mod. Sync. Reg.	-0.30	0.32	0.74	0.39 – 1.40
6m Sensitivity → Sync. Reg.	0.45†	0.25	1.57	0.97 – 2.54
6m Harsh-Intrusion → Sync. Reg.	0.52*	0.25	1.68	1.04 – 2.73
6m Sensitivity → Low React. Reg.	-0.13	0.51	0.88	0.32 – 2.39
6m Harsh-Intrusion → Low React. Reg.	0.34	1.03	1.41	0.19 – 10.57
15 months (Sync. Reg. Reference)				
6m Sensitivity → Non-React.	-0.45†	0.25	0.64	0.39 – 1.04
6m Harsh-Intrusion → Non-React.	-0.52*	0.25	0.59	0.37 – 0.96
6m Sensitivity → Sync. React.	-0.22	0.28	0.81	0.47 – 1.39
6m Harsh-Intrusion → Sync. React.	-0.41	0.28	0.66	0.38 – 1.15
6m Sensitivity → Mod. Sync. Reg.	-0.22	0.36	0.81	0.40 – 1.62
6m Harsh-Intrusion → Mod. Sync. Reg.	-0.82*	0.40	0.44	0.20 – 0.96
6m Sensitivity → Low React. Reg.	-0.58	0.57	0.56	0.18 – 1.70
6m Harsh-Intrusion → Low React. Reg.	-0.18	1.07	0.83	0.10 – 6.75
24 months (Non-React. Reference)				
6m Sensitivity → Mod. Async. Reg.	-0.12	0.24	0.68	0.55 – 1.44
6m Harsh-Intrusion → Mod. Async. Reg.	0.12	0.21	0.98	0.75 – 1.69
6m Sensitivity → Async. Reg.	0.13	0.24	1.06	0.71 – 1.83
6m Harsh-Intrusion → Async. Reg	-0.05	0.22	1.33	0.62 – 1.47
6m Sensitivity → Sync. Reg.	-0.17	0.32	0.93	0.46 – 1.57
6m Harsh-Intrusion → Sync. Reg.	-0.10	0.26	1.44	0.54 – 1.51
15m Sensitivity → Mod. Async. Reg.	-0.38	0.25	0.89	0.42 – 1.12
15m Harsh-Intrusion → Mod. Async. Reg.	-0.02	0.23	1.13	0.63 – 1.54
15m Sensitivity → Async. Reg.	0.06	0.24	1.14	0.67 – 1.68
15m Harsh-Intrusion → Async. Reg	0.28	0.23	0.96	0.84 – 2.09
15m Sensitivity → Sync. Reg.	-0.07	0.35	0.85	0.47 – 1.84
15m Harsh-Intrusion → Sync. Reg.	0.36	0.31	0.90	0.79 – 2.61

Note. 6m = 6 months old, 15m = 15 months old. Confidence intervals refer to the reported odds ratios.
* *p* < .05; ** *p* < .01; *** *p* < .001; † *p* < .10

Table 6 (continued)

Parameter	Effects			
	b	SE	Odds Ratio	95% CI
24 months (Sync. Reg. Reference)				
6m Sensitivity → Non-React.	0.17	0.32	1.18	0.34 – 2.19
6m Harsh-Intrusion → Non-React.	0.10	0.26	1.11	0.66 – 1.85
6m Sensitivity → Mod. Async. Reg.	0.04	0.35	1.05	0.53 – 2.09
6m Harsh-Intrusion → Mod. Async. Reg.	0.22	0.27	1.25	0.73 – 2.13
6m Sensitivity → Async. Reg.	0.30	0.33	1.35	0.70 – 2.59
6m Harsh-Intrusion → Async. Reg	0.06	0.29	1.06	0.60 – 1.87
15m Sensitivity → Non-React.	0.07	0.35	1.07	0.54 – 2.11
15m Harsh-Intrusion → Non-React.	-0.36	0.31	0.70	0.38 – 1.26
15m Sensitivity → Mod. Async. Reg.	-0.31	0.37	0.73	0.36 – 1.50
15m Harsh-Intrusion → Mod. Async. Reg.	-0.38	0.31	0.68	0.37 – 1.26
15m Sensitivity → Async. Reg.	0.13	0.35	1.14	0.57 – 2.27
15m Harsh-Intrusion → Async. Reg	-0.08	0.32	0.92	0.49 – 1.73

Note. 6m = 6 months old, 15m = 15 months old. Confidence intervals refer to the reported odds ratios.
* $p < .05$; ** $p < .01$; *** $p < .001$; $^{\dagger} p < .10$

Table 7. Robust Maximum Likelihood Estimates of the Emotion Profiles on 15- and 24-Month Parenting

Parameter	Effects		
	Mean Difference	χ^2	Cohen's *d*
6m Emotion Profiles → 15m Sensitivity			
Mod. Async. Reg. vs. Non-React.	0.08	1.52	0.14
Async. Reg. vs. Non-React.	0.08	1.64	0.15
Sync. Reg. vs. Non-React.	0.36	10.60**	0.64
Mod. Async. Reg. vs. Sync. Reg.	-0.28	5.41*	-0.50
Async. Reg. vs. Sync. Reg.	-0.28	6.16*	-0.49
Async. Reg. vs. Mod. Async. Reg.	0.00	0.00	0.01
6m Emotion Profiles → 15m Harsh-Intrusion			
Mod. Async. Reg. vs. Non-React.	0.00	0.00	0.01
Async. Reg. vs. Non-React.	-0.01	0.02	-0.02
Sync. Reg. vs. Non-React.	-0.30	17.92***	-0.51
Mod. Async. Reg. vs. Sync. Reg.	0.29	14.54***	0.51
Async. Reg. vs. Sync. Reg.	0.29	10.51**	0.49
Async. Reg. vs. Mod. Async. Reg.	-0.01	0.01	-0.01
15m Emotion Profiles → 24m Sensitivity			
Sync. React. vs. Non-React.	-0.09	1.13	-0.15
Mod. Sync. Reg. vs. Non-React.	0.04	0.16	0.07
Sync. Reg. vs. Non-React.	-0.03	0.04	-0.04
Low React. Reg. vs. Non-React.	-0.31	0.30	-0.52
Sync. React. vs. Sync. Reg.	0.11	0.54	0.19
Mod. Sync. Reg. vs. Sync. Reg.	0.07	0.21	0.12
Low React. Reg. vs. Sync. Reg.	-0.28	0.21	-0.47
Mod. Sync. Reg. vs. Sync. React.	-0.04	0.12	-0.07
Mod. Sync. Reg. vs. Low React. Reg.	0.35	0.32	0.59
Low React. Reg. vs. Sync. React.	-0.39	0.50	-0.67
15m Emotion Profiles → 24m Harsh-Intrusion			
Sync. React. vs. Non-React.	0.02	0.03	0.02
Mod. Sync. Reg. vs. Non-React.	0.05	0.10	0.06
Sync. Reg. vs. Non-React.	0.05	0.16	0.07
Low React. Reg. vs. Non-React.	0.15	0.18	0.21
Sync. React. vs. Sync. Reg.	0.03	0.05	0.04
Mod. Sync. Reg. vs. Sync. Reg.	0.00	0.00	0.01
Low React. Reg. vs. Sync. Reg.	0.10	0.08	0.14
Mod. Sync. Reg. vs. Sync. React.	0.03	0.03	0.04
Mod. Sync. Reg. vs. Low React. Reg.	-0.11	0.06	-0.15
Low React. Reg. vs. Sync. React.	0.14	0.14	0.19

Note. * $p < .05$, ** $p < .01$, *** $p < .001$, † $p < .10$

Table 8. Study 2 Bivariate Correlations

	1	2	3	4	5	6	7	8	9	10	11	12
1. Child race[a]	–											
2. Child sex[b]	.00	–										
3. State[c]	-.50***	-.08**	–									
4. Income-to-needs	-.33***	-.04	.17***	–								
5. Parent education	-.24***	.00	.16***	.62***	–							
6. ADHD	.06	-.15***	-.01	-.22***	-.24***	–						
7. ODD	-.07*	.01	.13***	-.13***	-.14***	.41***	–					
8. CD	.05	-.07	.08*	-.08*	-.12***	.27***	.34***	–				
9. CU behaviors	.01	-.06	.04	-.12***	-.14***	.24***	.31***	.24***	–			
10. CPs	.23***	.06*	-.07*	-.28***	-.30***	.31***	.31***	.20***	.28***	–		
11. Hyperactivity	.17***	-.03	-.06*	-.21***	-.28***	.50***	.24***	.21***	.18***	.54***	–	
12. LPB	.20***	.13*	-.08*	-.20***	-.21***	.22***	.20***	.14**	.22***	.54***	.44***	–
Number	1239	1239	1239	1236	1292	810	810	810	806	1174	1174	1173
Mean	0.23	0.48	0.59	2.16	13.02	0.38	0.35	0.10	0.20	0.23	0.22	0.88
Standard deviation	0.42	0.50	0.49	1.57	2.22	0.48	0.48	0.30	0.60	0.25	0.26	0.18

Note. ADHD = Attention-deficit/hyperactivity disorder, ODD = Oppositional defiant disorder, CU = callous-unemotional, CPs = Conduct problems, LPB = Limited prosocial behavior

[a] 0 = European American, 1 = African American. [b] 0 = male, 1 = female. [c] 0 = North Carolina, 1 = Pennsylvania

* $p < .05$, ** $p < .01$, *** $p < .001$, † $p < .10$

Table 9. Fit Statistics for Latent Class Analysis Models of Conduct Problems, Hyperactivity, and Limited Prosocial Behavior

Number of classes	BIC	ssBIC	aVLMR	Entropy
2	24595.55	24382.74	$p < .001$	.839
3	24188.17	23867.36	$p = .001$	.815
4	**23873.88**	**23445.07**	**$p = .612$**	**.798**
5	23895.07	23358.26	$p = .217$	.803
6	23965.52	23320.72	$p = .683$	.809
7	24051.27	23298.47	$p = .289$	.797

Note. BIC = Bayesian information criteria; ssBIC = Sample size-adjusted Bayesian information criteria; aVLMR = Adjusted Vuong-Lo-Mendell-Rubin likelihood ratio test

Bold indicates the final model selected based on theory, interpretability, and fit indices.

Table 10. Comparison of Hypothesized Conduct Problem/Hyperactivity/Limited Prosocial Behavior Trajectories to the Longitudinal Latent Class Analysis Estimated Trajectories

Hypothesized Trajectory	LLCA Support	LLCA Discrepancies from Hypothesized Groups	LLCA Group Name
(1) Stable low CPs, hyperactivity, and limited prosocial behavior	Full	This group is consistent with prediction	Stable Low
(2) Stable high CPs, hyperactivity, and limited prosocial behavior	Partial	A single group was found with teacher report of stable high CP, HY, and LPB; but parent rating was stable high only for CP and HY, LPB was low	Stable High
(3) Stable high CPs and hyperactivity, but low limited prosocial behavior	Partial		
(4) Decreasing CPs and hyperactivity, and stable low limited prosocial behaviors	Partial	This group had parent rating of high with slightly decreasing CP and HY, and low LPB; but teacher ratings were stable low for all three behaviors	Parent High Decreasing
(5) Increasing CPs and hyperactivity, and stable low limited prosocial behavior	Partial	Parent ratings were relatively low for all three behaviors; teacher ratings increased for all three behaviors	Teaching Increasing

Note. LLCA = Longitudinal latent class analysis, CPs = conduct problems, HY = hyperactivity, LPB = Limited prosocial behavior

Table 11. Robust Maximum Likelihood Estimates of Associations of SDQ Trajectories with ADHD, ODD, CD, and CU Behaviors at 12 Years Old

Parameter	Effects		
	χ^2	*p*-value	Odds ratio
ADHD			
Stable High vs. Stable Low	54.55	< .001	34.65
Parent High Decreasing vs. Stable Low	12.77	< .001	5.83
Teacher Increasing vs. Stable Low	18.09	< .001	7.02
Stable High vs. Teacher Increasing	10.44	.001	4.94
Stable High vs. Parent High Decreasing	10.71	.001	5.94
Parent High Decreasing vs. Teacher Increasing	0.14	.711	0.83
ODD			
Stable High vs. Stable Low	40.87	< .001	16.48
Parent High Decreasing vs. Stable Low	6.72	.010	4.32
Teacher Increasing vs. Stable low	4.78	.029	2.98
Stable High vs. Teacher Increasing	13.51	< .001	5.54
Stable High vs. Parent High Decreasing	5.33	.021	3.82
Parent High Decreasing vs. Teacher Increasing	0.43	.511	1.45
CD			
Stable High vs. Stable Low	15.65	< .001	16.13
Parent High Decreasing vs. Stable Low	2.57	.108	4.65
Teacher Increasing vs. Stable low	0.08	.777	1.40
Stable High vs. Teacher Increasing	10.69	.001	22.53
Stable High vs. Parent High Decreasing	2.91	.088	3.47
Parent High Decreasing vs. Teacher Increasing	2.65	.103	6.49
CU Behaviors			
Stable High vs. Stable Low	26.66	< .001	14.51
Parent High Decreasing vs. Stable Low	3.73	.054	4.16
Teacher Increasing vs. Stable low	0.01	.934	1.07
Stable High vs. Teacher Increasing	12.94	< .001	15.53
Stable High vs. Parent High Decreasing	3.52	.061	3.49
Parent High Decreasing vs. Teacher Increasing	2.23	.136	4.45

Note. SDQ = Strength and Difficulties Questionnaire, ADHD = Attention-deficit-hyperactivity disorder, ODD = oppositional defiant disorder, CD = Conduct disorder, CU = callous-unemotional

Table 12. Study 3 Bivariate Correlations

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Child race[a]	–												
2. Child sex[b]	.00	–											
3. State[c]	-.50***	-.08**	–										
4. Income	-.33***	-.04	.17***	–									
5. Parent ed.	-.24***	.00	.16***	.62***	–								
6. B. react.	.09**	-.04	.03	-.09*	-.11**	–							
7. C. react.	.05†	-.01	-.07*	-.08*	-.05	.25***	–						
8. ER	.01	.02	.03	.12**	.02	.37***	.12**	–					
9. Baseline	-.11***	.00	.11**	.20***	.18***	-.03	.05	-.02	–				
10. EF	-.31***	.12***	.28***	.27***	.33***	-.06	-.06†	.05	.14***	–			
11. CPs	.23***	.06*	-.07*	-.28***	-.30***	.06	.05	-.01	-.09**	-.28***	–		
12. HYP	.17***	-.03	-.06*	-.21***	-.28***	.07†	.05	-.05	-.09**	-.35***	.54***	–	
13. LPB	.20***	.13***	-.08*	-.20***	-.21***	.00	.06	-.03	-.07*	-.24***	.54***	.44***	–
Number	1239	1239	1239	1236	1292	826	896	839	1135	1121	1174	1174	1173
Mean	0.23	0.48	0.59	2.16	13.02	0.25	-0.04	0.56	5.16	-0.05	0.23	0.22	0.88
SD	0.42	0.50	0.49	1.57	2.22	0.27	0.72	0.47	1.27	0.42	0.25	0.26	0.18

Note. Parent ed. = Parent years of education, B. react. = Behavioral reactivity, C. react. = Cortisol reactivity, ER = Emotion regulation, Baseline = Time of day baseline cortisol was collected , EF = Executive function, CPs = Conduct problems, LPB = Limited prosocial behavior

[a] 0 = European American, 1 = African American. [b] 0 = male, 1 = female. [c] 0 = North Carolina, 1 = Pennsylvania

* $p < .05$, ** $p < .01$, *** $p < .001$, † $p < .10$

Table 13. Estimated Transition Probabilities of CP/Hyperactivity/Limited Prosocial Membership Based on 24-Month Emotion Profile Membership

	24-Month Emotion Profiles			
	Non-React.	Mod. Async. Reg.	Async. Reg.	Sync. Reg.
SDQ Trajectories				
Stable Low	0.43	0.42	0.40	0.39
Stable High	0.11	0.18	0.16	0.19
Parent High Decreasing	0.21	0.23	0.31	0.19
Teacher Increasing	0.25	0.16	0.13	0.24

Note. Non-React. = Non-reactors, Mod. Async. Reg. = Moderate Asynchronous Regulators, Async. Reg. = Asynchronous Regulators, Sync. Reg. = Synchronous Regulators. The transition probabilities for each group do not always add to exactly 1, due to rounding error.

Table 14. Robust Maximum Likelihood Estimates of Emotion Profiles on Executive Function and of Executive Function on Conduct Problem/Hyperactivity/Limited Prosocial Behavior Trajectories

Parameter	Effects		
	Mean Difference	χ^2	Cohen's *d*
Emotion Profiles → Executive Function			
Mod. Async. Reg. vs. Non-React. → EF	-0.01	0.06	-0.03
Async. Reg. vs. Non-React. → EF	0.09	$3.70^{\dagger}$	0.22
Sync. Reg. vs. Non-React. → EF	-0.04	0.39	-0.10
Mod. Async. Reg. vs. Sync. Reg. → EF	0.03	0.13	0.07
Async. Reg. vs. Sync. Reg. → EF	0.13	$3.45^{\dagger}$	0.32
Mod. Async. Reg vs. Async. Reg. → EF	-0.10	$2.90^{\dagger}$	-0.25

	b	SE	Odds Ratio	95% CI
Executive Function → SDQ Trajectories				
EF → Stable Low vs. Stable High	2.74***	0.39	15.63	7.19 – 33.33
EF → Stable Low vs. Parent High Decreasing	1.36***	0.36	3.90	1.95 – 7.81
EF → Stable Low vs. Teacher Increasing	1.51***	0.37	4.50	2.20 – 9.26
EF → Parent High Decreasing vs. Stable High	1.38***	0.34	3.98	2.04 – 7.75
EF → Teacher Increasing vs. Stable High	1.24***	0.35	3.45	1.74 – 6.83
EF → Parent High Decreasing vs. Teacher Increasing	0.14	0.34	1.15	0.48 – 2.25

Note. Non-React. = Non-reactors, Mod. Async. Reg. = Moderate Asynchronous Regulators, Async. Reg. = Asynchronous Regulators, Sync. Reg. = Synchronous Regulators, EF = Executive Function. Confidence intervals refer to the reported odds ratios.
* $p < .05$; ** $p < .01$; *** $p < .001$; † $p < .10$

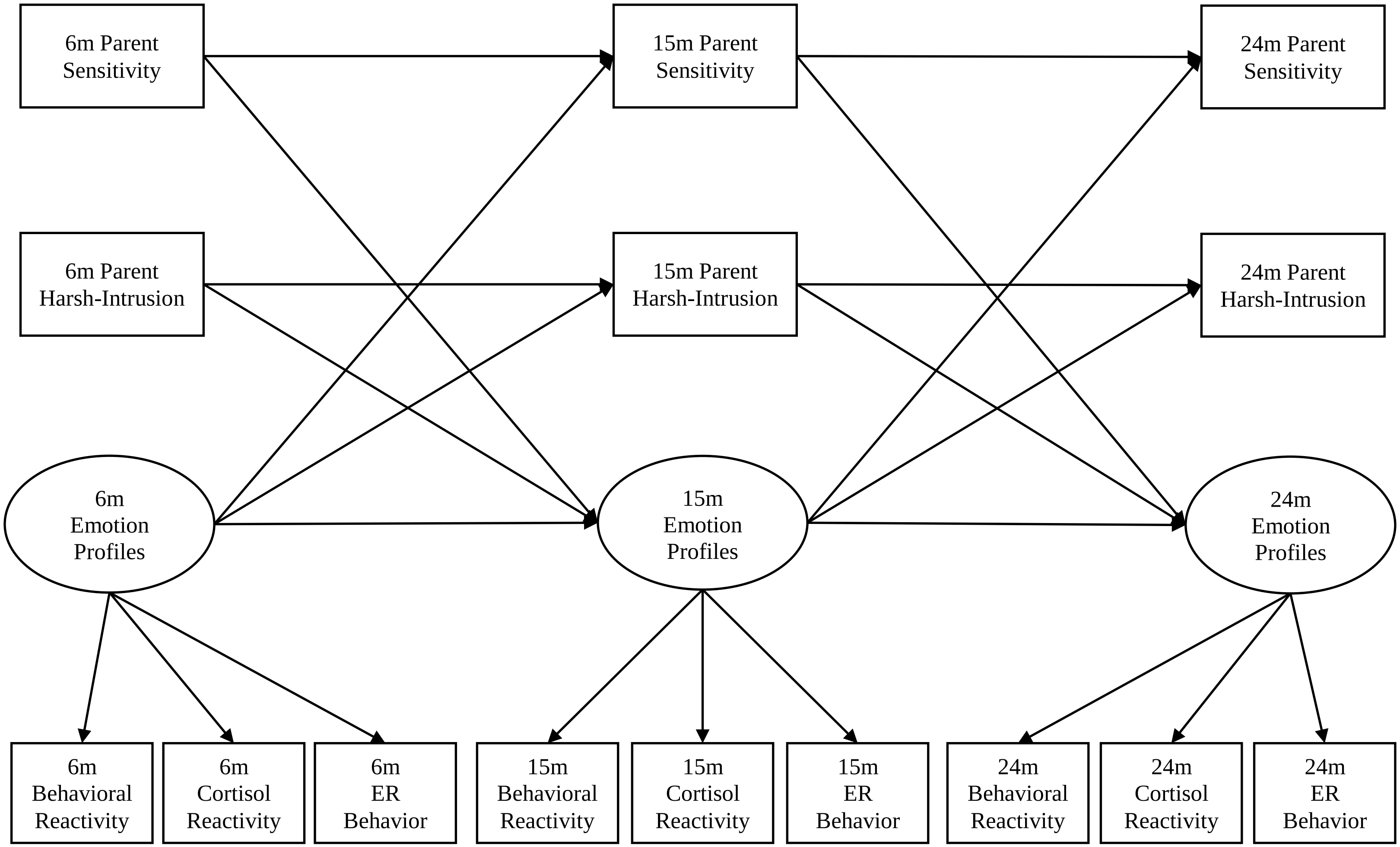

Figure 1. Study 1 Conceptual Model
Note. 6m = 6 months old; 15m = 15 months old; 24m = 24 months old; ER = Emotion regulation.
Concurrent associations will be tested, but are not depicted in order to enhance readability.

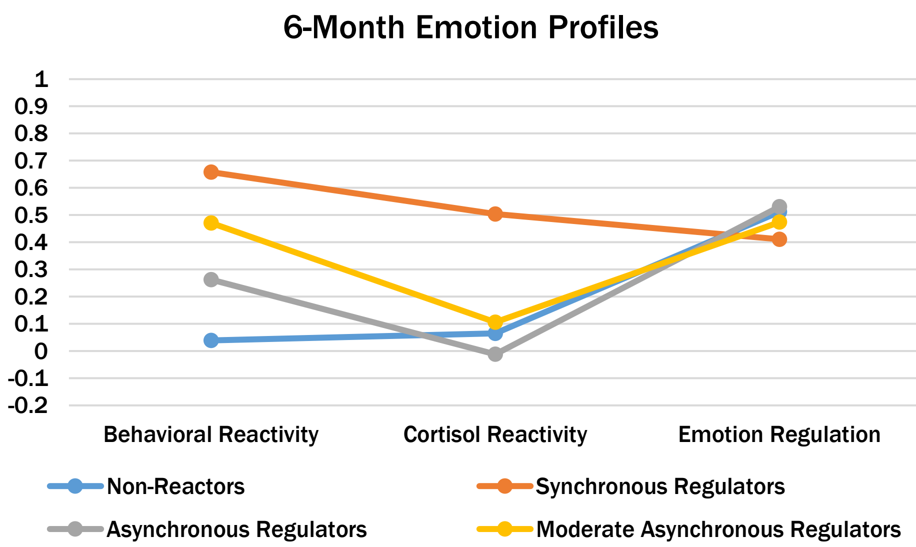

Figure 2. 6-Month Emotion Profiles
Note. Values of behavioral reactivity and emotion regulation represent the proportion of time spent engaging in each during the challenge task. Values of cortisol reactivity above 0 represent an increase in cortisol from baseline to post-task and values below 0 represent a decrease in cortisol from baseline to post-task.

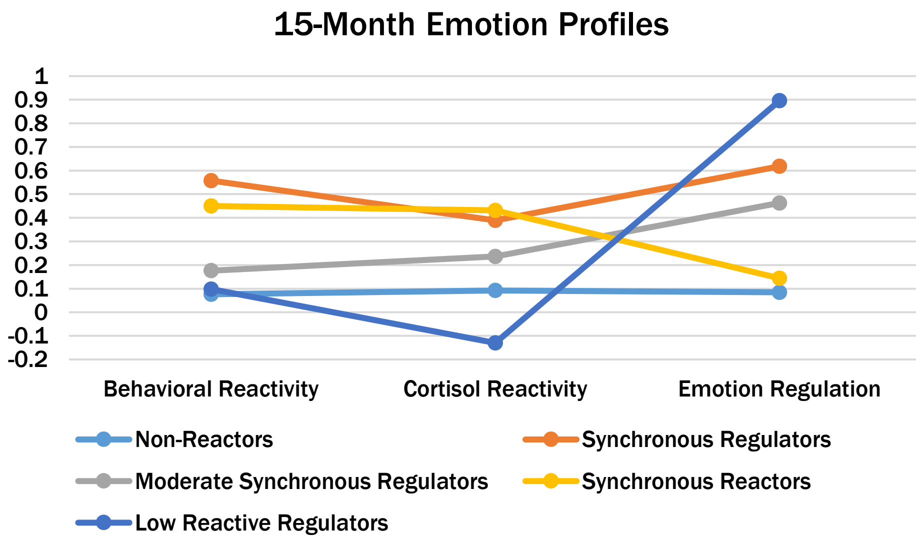

Figure 3. 15-Month Emotion Profiles
Note. Values of behavioral reactivity and emotion regulation represent the proportion of time spent engaging in each during the challenge task. Values of cortisol reactivity above 0 represent an increase in cortisol from baseline to post-task and values below 0 represent a decrease in cortisol from baseline to post-task.

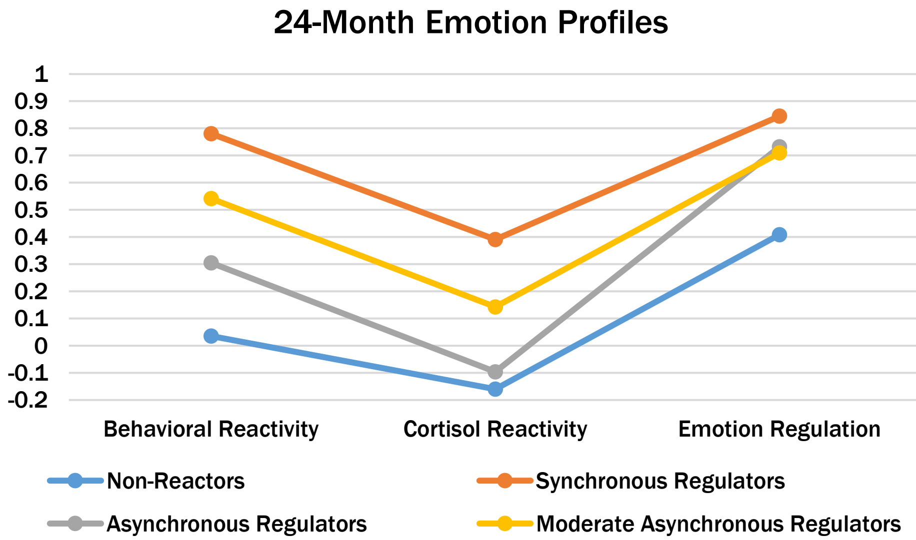

Figure 4. 24-Month Emotion Profiles

Note. Values of behavioral reactivity and emotion regulation represent the proportion of time spent engaging in each during the challenge task. Values of cortisol reactivity above 0 represent an increase in cortisol from baseline to post-task and values below 0 represent a decrease in cortisol from baseline to post-task.

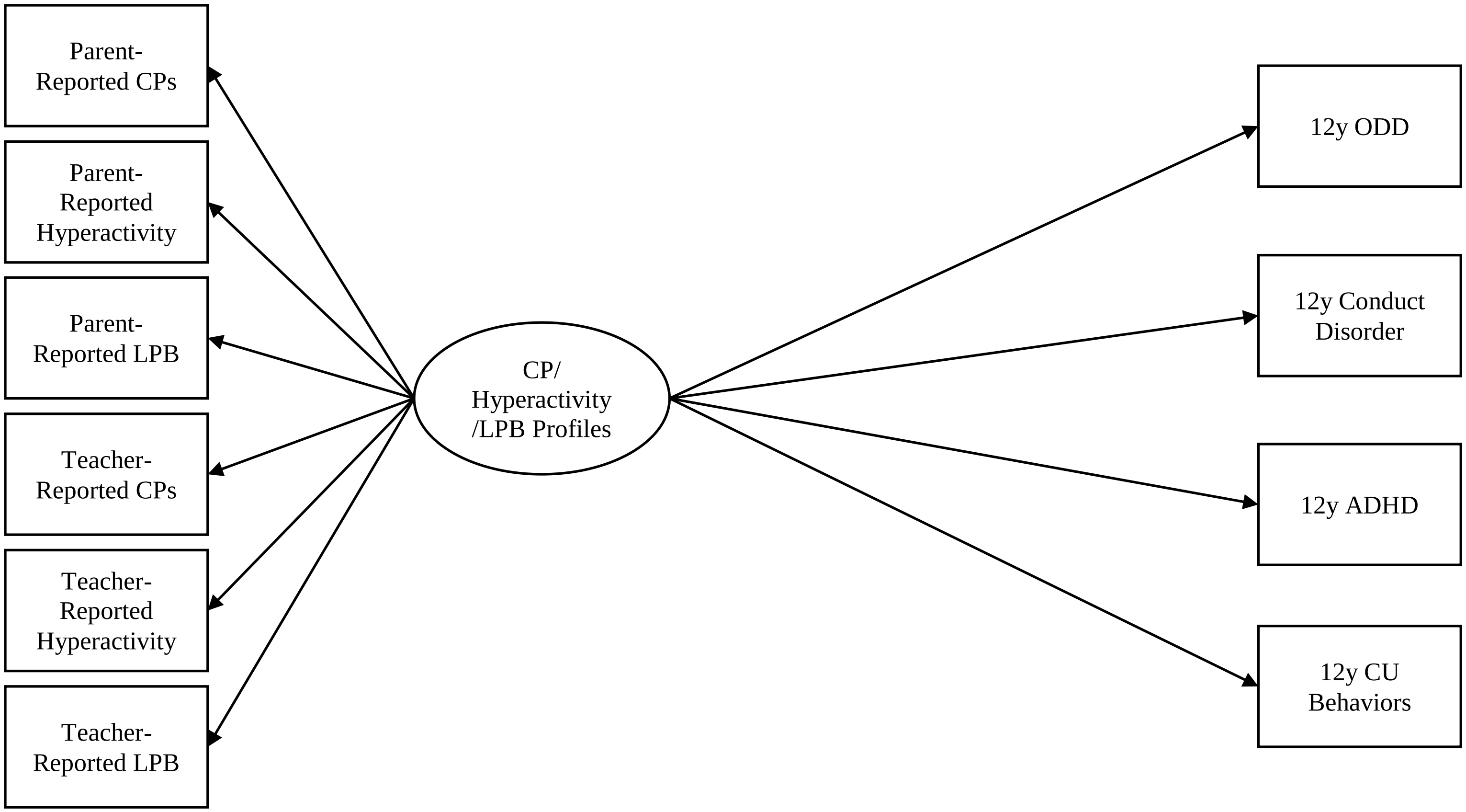

Figure 5. Study 2 Conceptual Model

Note. CPs = Conduct problems; LPB = Limited prosocial behavior; ODD = Oppositional defiant disorder; ADHD = Attention-deficit/hyperactivity disorder; 12y = 12 years old.

To enhance readability, six indicators are depicted for the profiles, but each one represents the indicators for the construct at all ages from 36 months to 5th grade (36 indicators total).

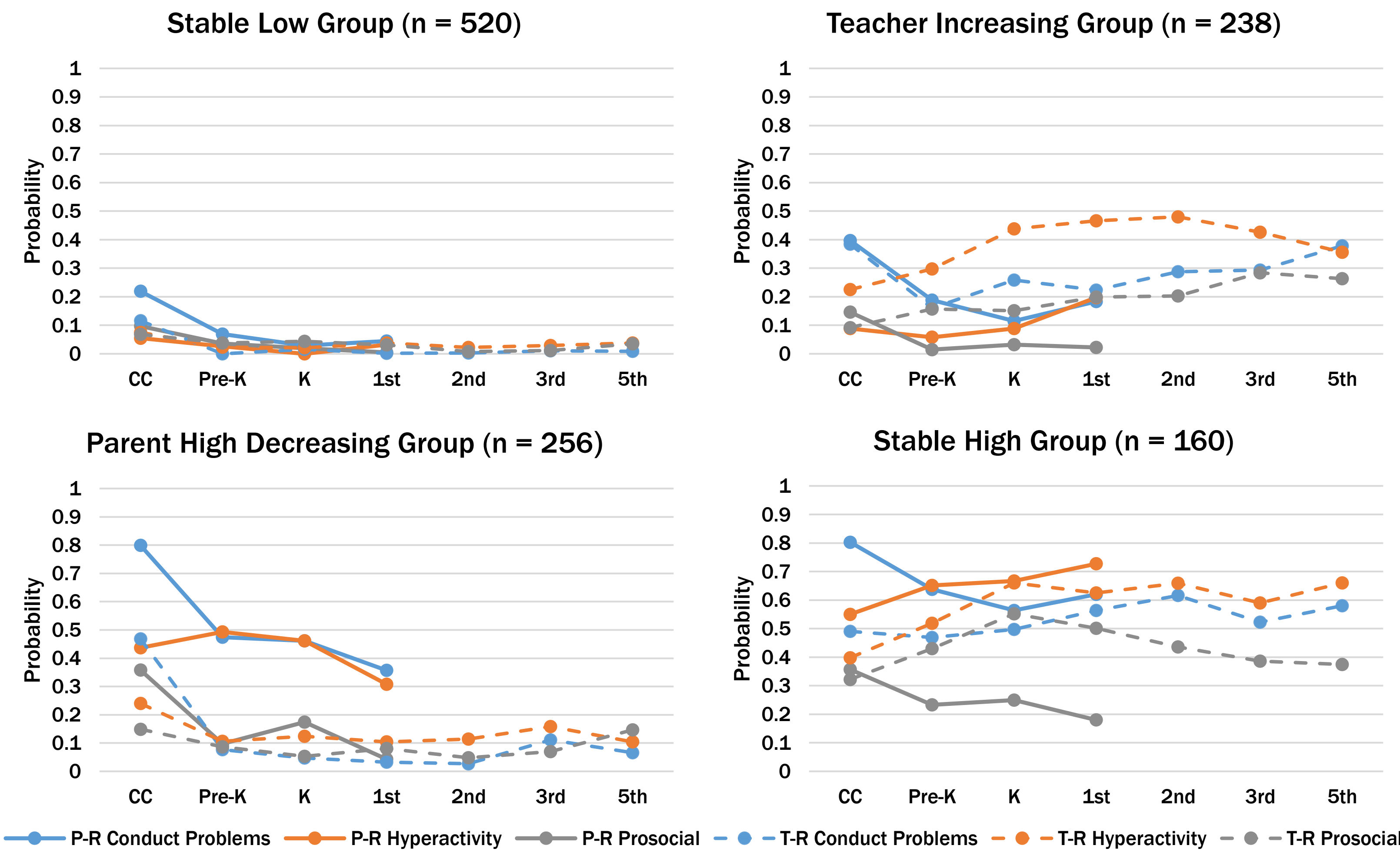

Figure 6. Conduct Problem/Hyperactivity/Limited Prosocial Behavior Trajectories
Note. CC = Childcare, Pre-K = Pre-Kindergarten, K = Kindergarten, 1st = First grade, 2nd = Second grade, 3rd = 3rd grade, 5th = Fifth grade, P-R = Parent-report, T-R = Teacher-report

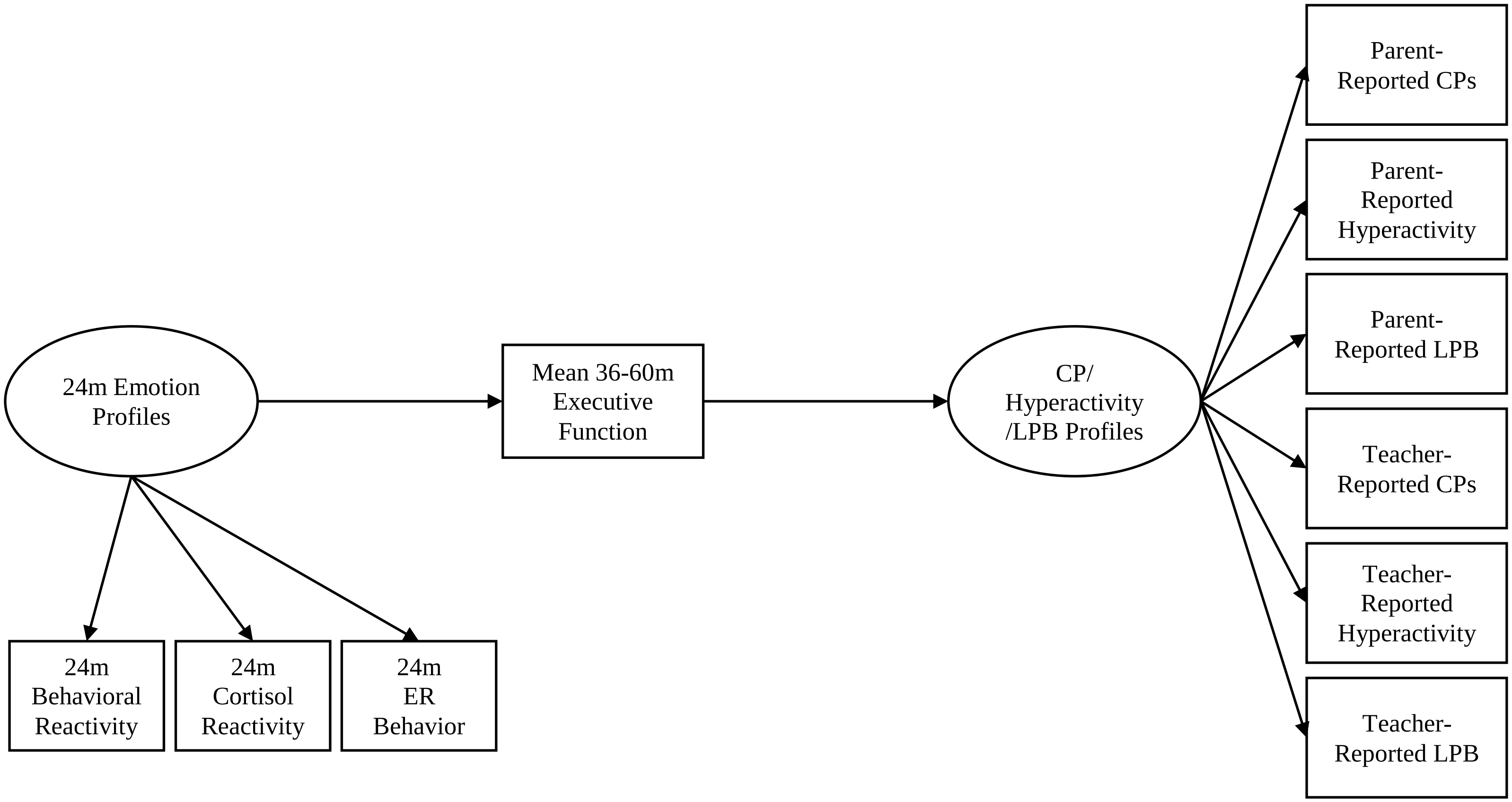

Figure 7. Study 3 Conceptual Model

Note. 24m = 24 months old; 36m = 36 months old; 60m = 60 months old; CPs = Conduct problems; LPB = Limited prosocial behavior; To enhance readability, six indicators are depicted for the CP/hyperactivity/LPB profiles, but each one represents the indicators for the construct at all ages from 36 months to 5th grade (36 indicators total).